Food and Agriculture Organization of the United Nations

United Republic of Tanzania

Forests for a sustainable future

EDUCATION MODULES FOR PRIMA RY SCHOOLS

Teacher's book

MODULE 1

FOREST PRODUCTS, PLANTS AND ANIMALS

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Forests for a sustainable future

EDUCATION MODULES FOR PRIMARY SCHOOLS

Teacher's book

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FOREST PRODUCTS, PLANTS
AND ANIMALS

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Contents

Foreword v
Acknowledgements vi
Introduction 1

Chapter 1. Introduction to forests and their biodiversity 5
Lesson 1. What can we find in a forest? 10
Lesson 2. Create a forest layers memory game 13
Lesson 3. Play a forest layers memory game 15

Chapter 2. What is a tree? 19
Lesson 4. What makes a tree? 24
Lesson 5. Create the living picture of a tree 28
Lesson 6. Plant a class tree 31

Chapter 3. Forests and soil 53
Lesson 7. Why does soil matter? 58
Lesson 8. Make a soil profile 60
Lesson 9. What is soil made of? 63
Lesson 10. How do forests and soil interact? 67

Chapter 4. Animals in the forest 73
Lesson 11. Focus on forest animals 78
Lesson 12. How many forest animals can you name? 81
Lesson 13. Play a forest animal miming game 83
Lesson 14. Become a forest animal expert 85

Chapter 5. The life of bees in a colony 89
Lesson 15. Prepare for a bee colony role play 94
Lesson 16. Make hats for a bee colony role play 98
Lesson 17. Perform a bee colony role play 100
Lesson 18. What did you learn from the role play? 103

Chapter 6. Pollination and bee products 107
Lesson 19. What do we use bee products for? 112
Lesson 20. Play a honeybee pollinator game 115
Lesson 21. What is pollination? 117

Chapter 7. Beekeeping **121**
Lesson 22. What does a beekeeper do? 126
Lesson 23. What equipment does a beekeeper need? 132
Lesson 24. Discover a beekeeper's year 135

Chapter 8. Forest products **153**
Lesson 25. What products come from the forest? 158
Lesson 26. Create a forest product matching game 160
Lesson 27. Play a forest product matching game 162

Chapter 9. Our forests in the United Republic of Tanzania **165**
Lesson 28. What do you know about Tanzanian forests? 170
Lesson 29. Discover the tree species in Tanzanian forests 173
Lesson 30. Play a wood resource catching game 175

Tables

Table 5.1.
Roles in the play about bees, and the hats for each role 97

Table 5.2.
Hats for the play 99

Table 7.1.
Beekeepers' tools 133

Table 8.1.
Wood and non-wood products harvested in forests 156

Foreword

Teaching young people about protecting and sustainably managing forests is vital for our future.

Forests play important roles in our daily lives – they are a source of food, wood, medicines and energy for billions of people worldwide, and they host more than three-quarters of the world's terrestrial biodiversity. By sequestering carbon and influencing microclimates, forests help mitigate climate change; moreover, forests help communities adapt to climate change and increase their resilience to climate-related shocks.

The key to maintaining forests and their benefits over time is to manage them sustainably – this means ensuring that what is harvested in a forest is allowed to grow back and that the many values of forests are maintained over time. Today, however, people are increasingly disconnected from nature and lack awareness of forests and their benefits.

Forest education builds the knowledge, skills and shared values that underpin sustainable forestry and its contributions to sustainable development goals, such as those set out in the 2030 Agenda for Sustainable Development. In recent years, however, international forums have expressed concern that, in most countries, forest-related education is insufficient and outdated. The net result in a lack of awareness and understanding among people of all ages of the importance of forests.

Providing children with an understanding of the vital roles of forests is crucial for safeguarding natural resources for future generations. But the Global Assessment of Forest Education, published by the Food and Agriculture Organization of the United Nations (FAO) in 2022, reported that, in Africa, resources and learning materials for forest education in primary schools are absent or available to only a limited extent. The assessment also found that a lack of awareness-raising about nature in primary schools has contributed to a low level of interest in forest education.

It is essential that children in primary schools today learn about forests so they know why forests matter and how they can be used sustainably and thereby protected and maintained over time. Moreover, inspiring children from an early age about forests can help open new horizons and influence career pathways. When young people have a clear picture of forestry and the sector's role in solving sustainable development challenges, they are more likely to consider forestry as a viable career choice.

The education modules presented here are designed for children aged 9–12 in grades 3–5. They will increase the forest literacy of the children and, in the long term, enhance their capacity to make decisions in favour of sustainable forest use. The modules are inspired by the principles of the "education for sustainable development" (ESD) approach, which is based on learning methods that motivate and empower learners to make informed decisions, change their behaviour, and take responsible action for the benefit of the present and future generations. They use a more hands-on and interactive approach than standardized education methods.

The modules have been developed by the Ministry of Natural Resources and Tourism of the United Republic of Tanzania in the framework of the project, "Forests for a Sustainable Future: Educating Children", with technical contributions by FAO and the support of the German Federal Ministry for Food and Agriculture.

Nyabenyi Tito Tipo

FAO Representative in the
United Republic of Tanzania

November, 2023

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Introduction

The method: encouraging children to be problem solvers

The ESD approach emphasizes skills, abilities and values such as empathy, self-reflection, critical thinking, collaborative decision-making, and taking responsibility for present and future generations. This requires a shift towards active, participative and experiential learning methods that engage the learner and make a real difference to their understanding, thinking and ability to act. Using this approach, teachers help pupils develop their abilities to recognize, analyse and assess the sustainability of processes and practices. This should enable them to adopt sustainable practices in their own lives and to play an active part in sustainable development, locally and globally.

Through ESD activities, teachers motivate pupils to be open to different perspectives and new information. The ESD approach aims to develop the ability of pupils to solve problems and use fact-based knowledge in taking action. The box sets out key aspects of the ESD approach.

The "education for sustainable development" teaching approach

Teacher's role and approach

- The teacher acts as a partner for self-reflection.
- The teacher encourages pupils to come up with solutions rather than demanding answers.
- The teacher provides prompts and guidance rather than definitions.
- The teacher's instructions purposefully lack context to encourage a pupil's ability to infer it autonomously.
- The teacher trusts pupils' capabilities and skills and treats them with patience and understanding.

Pupils are encouraged to:

- be open to the world and to integrate new perspectives;
- think and act in a forward-looking manner;
- acquire knowledge and act in an interdisciplinary manner;
- learn how to deal with incomplete and overly complex information;
- approach decision-making processes in a cooperative manner;
- learn how to cope with dilemmas in decision-making situations;
- take part in collective decision-making processes;
- self-motivate to take action and spur others to do the same;
- reflect on their own principles and those of others;
- ground all decision-making and planning actions in the notion of equity;
- plan and act autonomously; and
- show empathy and solidarity towards people in need.

Pupils learn better when:

- The environment promotes their active participation and action-oriented learning.
- Learning takes place in a participatory way and involves everyone.
- They are encouraged to reflect on what has been learned and on the values and perspectives of everyone.
- The learning topics:
  - » take past experiences and cultural factors into account;
  - » are significant in the pupils' daily lives;
  - » directly affect and are interesting to the pupils;
  - » can be linked to existing knowledge; and
  - » are analysed in an interdisciplinary manner and from different perspectives.

The structure: how the learning is organized

To maximize the probability of successful learning outcomes, the forest education modules follow precise didactic criteria and have a distinctive structure.

The forest education material comprises three modules, each aimed at a specific primary-school grade level: Module 1 – Grade 3; Module 2 – Grade 4; and Module 3 – Grade 5.

The central themes of all three modules are the multiple functions of forests and the importance of their sustainable management. Each module also explores a specific theme, as follows:

- **Module 1: Forest products, plants and animals (biodiversity).** Pupils learn about animals and plants that live in forests.
- **Module 2: Forests, health and well-being.** Pupils learn about the benefits (also called ecosystem services) that forests offer people in their daily lives.
- **Module 3: Forests and the climate.** Pupils learn how climate and forests are related and why forest protection and sustainable use are important for the climate.

The modules consist of chapters, with each chapter containing three or four lessons of 40 minutes each. Each chapter follows the same pattern: a first lesson in which the teacher introduces a topic; one or two practical lessons in which the pupils explore the topic through games and activities; and a final lesson for reflection and discussion.

In total, the three modules contain 26 chapters. Each module has its own teacher's and pupils' books, as described below.

Teacher's books

Each teacher's book consists of chapters and a glossary. Each chapter contains an appendix that collates the various photographic images used in the chapter, which may be cut out and used in specific lessons as visual aids.

Each chapter has the same structure, as follows:

- An **overview** of the content, which summarizes the topic addressed in the chapter and the proposed activities.
- **Objectives**, which set out three or four key skills and learnings that the pupils will acquire from the chapter.
- **Background information** comprising three paragraphs to provide teachers with explanations of the topics addressed in the chapter, as well as photographs as visual aids. The background information does not necessarily reflect the flow of a chapter's activities. The latter follow a pedagogical logic and the former presents information sequentially, from simple to complex, to make the text more readable and understandable. Where applicable, the background information contains cross-references to relevant chapters in the same module; these connections enable the teachers to gain a deeper understanding of the contents and, if desired, to make pupils aware of related topics that will be covered later in the course. Although most of the information needed to perform the lessons is included in the activities, teachers are advised to read the background information before teaching the chapter to obtain a preliminary understanding of the topic and to enable them to better answer pupils' questions during the lessons.
- Three or four **lessons** designed to span 40 minutes each. The lessons comprise discussions, drawing, memory games, quizzes and other activities. Typically, the first lesson of a chapter introduces the topic to the

pupils and is designed to build their interest and motivation for the subject through exercises and activities. The activities in the second lesson (and third lesson, where applicable) aim to deepen competencies, and the last lesson encourages reflection and discussion. From this structure, pupils acquire and deepen their knowledge of the chapter's topic while also linking it to related themes. Each activity includes an indication of the time that should be allocated to it, as well as whether it should be performed indoors or outdoors.

- **Activities** present detailed instructions for teachers to follow when engaging with pupils. Where applicable, activities have lists of **required materials**, presented with simple illustrations. A section titled **preparation for the lesson** provides teachers with information on the preparation needed beforehand (although not all lessons require preparation). The expected duration and recommended setting (whether indoors or outdoors) are specified for each activity.

This icon indicates activities best conducted in the classroom.

This icon indicates activities best conducted in the schoolyard – for example, they may require more space for the pupils or are designed to enable pupils to interact with the natural environment.

- A section titled **preparation for the next lesson**. This is included at the end of most lessons and chapters to alert teachers to the need to prepare in advance for following lessons or to bring materials to school (or to ask pupils to do so). Teachers are strongly encouraged to read the instructions well in advance of lessons to ensure adequate preparation.

The teacher's books are colour-coded (yellow for Module 1, orange for Module 2 and green for Module 3), and icons are used to help teachers navigate information while teaching. Background information and preparatory instructions have a coloured background, and instructions for conducting the lessons have a white background.

Pupil's books

All lessons have been structured to be taught without the need of a pupil's book. However, to support children in following the lessons, a pupil's book has been developed for optional use.

The pupil's books are based on the corresponding teacher's books and are designed to serve as a reference for pupils, guide them through activities and help them follow the teacher's instructions.

The pupil's books contain instructions, photographs and drawings to support the pupils in carrying out activities. The children will not write in the pupils' books directly; rather, they will be prompted to write (or draw) in their exercise books where necessary.

Except for the background information, the pupil's books follow the same structure as the teacher's books, with icons helping pupils distinguish the type of activity that they are being asked to perform. For activities that require pupils to make drawings in their notebooks, simple, stylized examples are provided.

Chapter titles, by module

Module 1
Forest products, plants and animals (biodiversity) – Grade 3

In this module, pupils learn about the animals and plants that live in forests.

Chapter 1: Introduction to forests and their biodiversity
Chapter 2: What is a tree?
Chapter 3: Forests and soil
Chapter 4: Animals in the forest
Chapter 5: The life of bees in a colony
Chapter 6: Pollination and bee products
Chapter 7: Beekeeping
Chapter 8: Forest products
Chapter 9: Our forests in the United Republic of Tanzania

Module 2
Forests, health and well-being – Grade 4

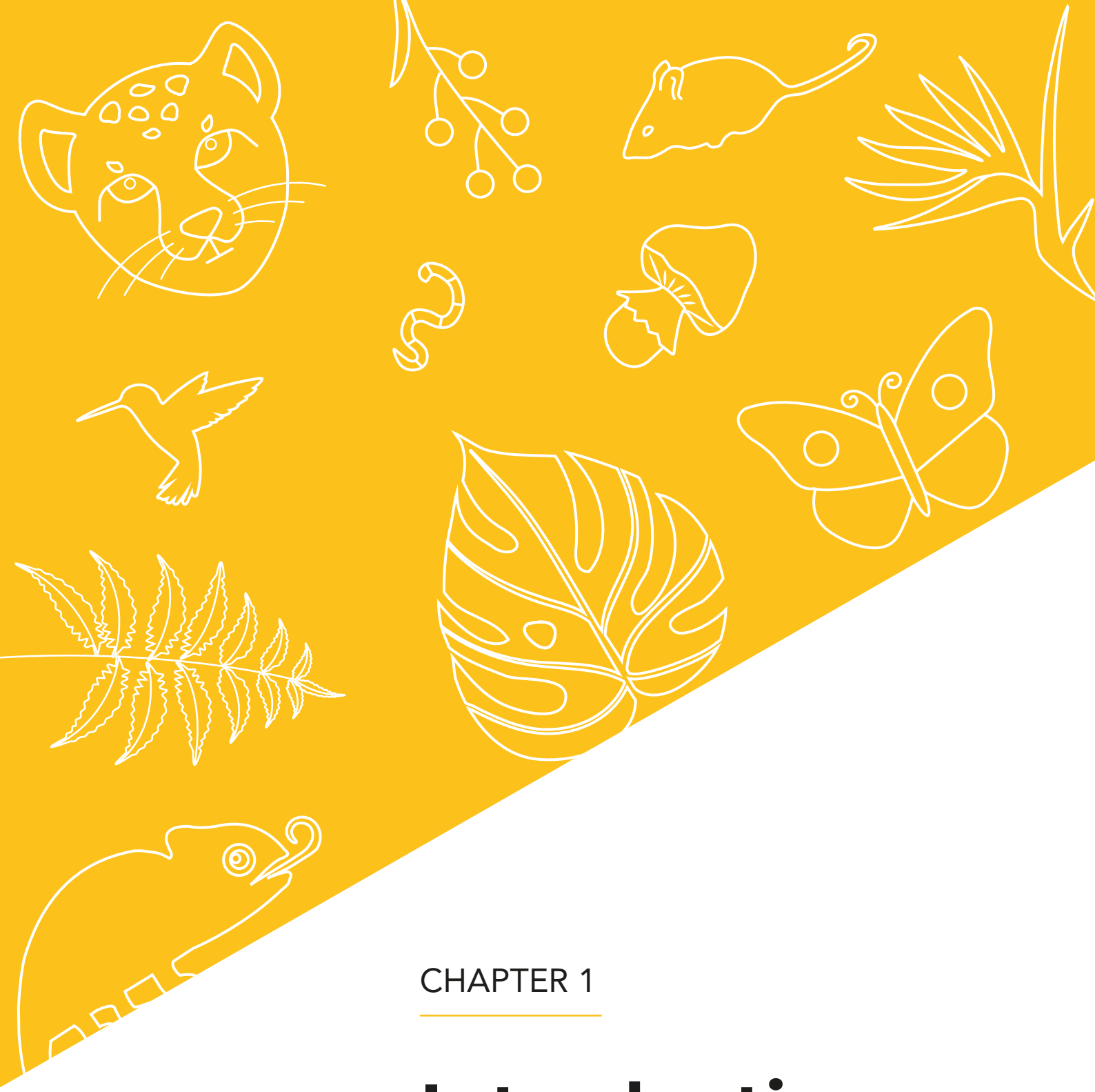
In this module, pupils learn about the benefits that forests offer people in their daily lives.

Chapter 1: The benefits of forests
Chapter 2: Food from the forest
Chapter 3: Edible insects
Chapter 4: Hunting
Chapter 5: Forests and water
Chapter 6: Medicinal plants
Chapter 7: Wood products
Chapter 8: Wood processing
Chapter 9: Forests and livelihoods

Module 3
Forests and the climate – Grade 5

In this module, pupils learn how climate and forests interact and why forest protection and sustainable use are important for the climate.

Chapter 1: Weather, climate and forests
Chapter 2: The greenhouse effect and climate change
Chapter 3: Photosynthesis
Chapter 4: Wood and other sources of renewable energy
Chapter 5: Sustainable forest management
Chapter 6: Forest and beekeeping laws
Chapter 7: The work of a forester
Chapter 8: Forests and climate change – What we can do



CHAPTER 1

Introduction to forests and their biodiversity

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Overview

In this chapter, the pupils will learn that forests are habitats for many plants and animals. They will explore the structure of a typical forest and reinforce their learning about the various types of plants and animals found in forests through drawings, a memory game, and discussion and reflection. Specific reference will be made to the animals and plants found in Tanzanian forests.

Objectives

By the end of the chapter, the pupils will be able to:

- explain what a forest is;
- identify and describe the layers that can form in a forest; and
- identify typical plants, animals and other organisms in each forest layer, especially those found in the United Republic of Tanzania.

Background information

What is a forest?

A forest is a group of trees growing closely together.[i] The trees may have established naturally, or they may have been planted by people.

Forests cover nearly one-third of the Earth's land – more than 4 billion hectares.[1] This is equivalent to about half a hectare of forest for every person on the planet. Forests can grow in dry, wet, cold and hot climates. They vary substantially depending on the climate and many other factors, and different types of forest host different plants, animals and other living things.

The world's forests contain approximately 60 000 tree species,[2] as well as many other types of plants, such as shrubs, vines, ferns and mosses. Forests are also home to many mammals, reptiles, amphibians, birds, insects and other animals. Worldwide, most animals that live on land are found in forests, including 80 percent of amphibian species, 75 percent of bird species and 68 percent of mammal species (see Chapter 4).[3] Many species of fungi and lichen occur in forests. All these living things depend on each other to survive, and together they form the biodiversity of forests.

Types of forest in the United Republic of Tanzania include deciduous miombo woodlands, mangroves, lowland closed-canopy forests, montane forests and plantations (see Chapter 9).

[i]. Technical definitions of a forest exist that specify the minimum area of land with trees, the minimum height of the trees, the minimum canopy cover and other aspects – FAO's definition is available here: www.fao.org/3/I8661EN/i8661en.pdf

How are forests structured?

A forest is like a large building with different floors or "layers". Typical forest layers include the forest floor, the understorey, the canopy and the emergent layer.

- The **forest floor** mainly comprises decomposing plant material such as leaves, bark, branches, fallen trees and other plants. The forest floor is where the roots of forest trees and other plants are anchored.
- The **understorey** is a dark, cool and often moist environment that exists above the forest floor but under the canopy layer.
- The **canopy layer** consists of the parts of trees called crowns – that is, their upper trunks, branches and leaves. This layer provides the rest of the forest with shade and protection from wind and the impacts of raindrops.
- The **emergent layer** is composed of the tops of the tallest trees in the forest, which poke out above the trees of the main canopy layer.

Not all forests have all these layers – it depends on the type of environment in which they grow and how they are managed. In general, however, the more layers a forest has, the more biodiversity it hosts. Tropical rainforests, which are the most biodiversity-rich type of forest, generally have all four forest layers.

Picture 1.1. Ngorongoro rainforest

Which organisms live in the different forest layers?

Each forest layer is home to different living organisms, including plants, animals and fungi. Some animals (such as monkeys and leopards) may inhabit several layers, and others may live in only one.

- **Forest floor.** Organisms that live in forest soils and litter, such as fungi, beetles, ants, spiders and earthworms, help decompose fallen leaves and branches and, in turn, are food for other animals. Many frogs use the forest floor as habitat, as do mammals such as elephants, lions, deer, rats and mice.
- **Understorey.** Diverse types of plants, such as mosses, ferns, shrubs and trees, live in forest understoreys. The understorey may also be home to snakes, lizards, frogs, tree frogs and spiders, as well as insects such as beetles and ants. Monkeys, gorillas and leopards may live partly in the understorey.

- **Canopy.** The canopy layer is used as habitat by insects such as bees, ants, beetles and butterflies, which, in turn, are sources of food for various birds, amphibians (e.g. tree frogs) and reptiles (e.g. snakes, lizards and chameleons), which may move between layers. Mammals such as bats, monkeys and leopards may use the canopy as habitat. In forests with dense canopies and understoreys, little sunlight reaches the ground, and the canopy layer might host organisms that need higher exposure to sunlight.
- **Emergent layer.** The emergent layer is home to birds such as hawks and eagles, flying insects such as butterflies, bats and certain monkeys.

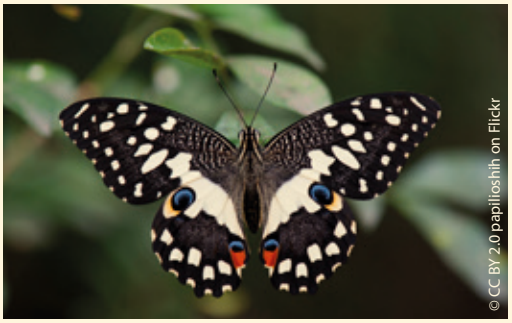
Picture 1.2. Earthworm

Picture 1.3. Elephants

Picture 1.4. Leopard

Picture 1.5. Tree frog

Picture 1.6. Lizard



Picture 1.7. Butterfly

Picture 1.8. Eagle

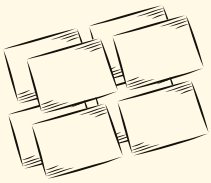
Picture 1.9. Bat

LESSON 1

What can we find in a forest?

1

Required materials



8 MANILA CARDS
(1 per pupil)

ADHESIVE TAPE

Preparation for the lesson

- Copy onto the board the drawing of a forest shown in Figure 1.1.

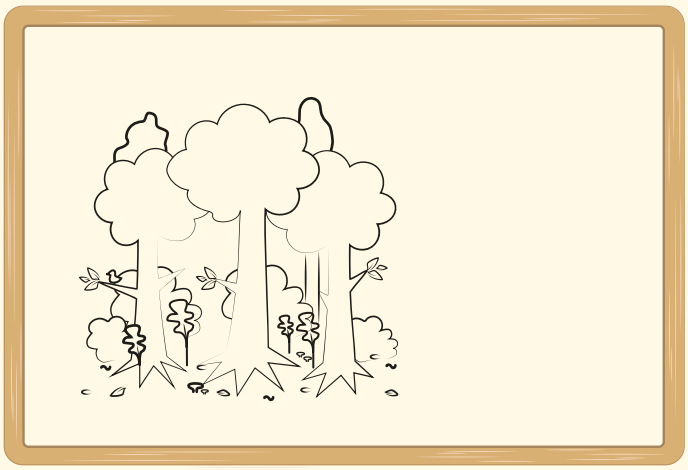


Figure 1.1. The basic features of a forest

- Prepare eight manila cards. Write in large letters the names of the following organisms (one on each card) commonly found in the various forest layers. Put adhesive tape on the back of each card. (In the list below, the forest layer in which the organism is found is written in brackets, but do not write this on the cards).

  - Earthworms (forest floor)
  - Elephants (forest floor)
  - Leopards (understorey + canopy)
  - Tree frogs (understorey + canopy)
  - Lizards (understorey + canopy)
  - Butterflies (canopy + emergent layer)
  - Bats (canopy + emergent layer)
  - Eagle (emergent layer)

1 Activity 1: Flashlight – Get into the topic

indoor

This activity should take **5 minutes**.

1. Tell the pupils that they will discover what a forest is.
2. Start with the question, "What can we find in a forest?"
3. Tell the pupils to give one-word answers only. Point in quick succession to pupils as they raise their hands. This will set the tone for the lesson and introduce the pupils to the topic. Possible answers include trees, shrubs, animals, birds, insects, stones, paths, water, herbs and soil.
4. **Explain:** A forest is a group of trees growing closely together. The trees may have established naturally, such as from seeds fallen from "parent" trees, or they may have been planted by people. In addition to trees, forests contain many other living organisms, such as shrubs, herbs, ferns and other plants, as well as animals and fungi. The pupils will discover more in the next activity.

2 Activity 2: Learn about forest layers

indoor

This activity should take **20 minutes**.

1. Point to the drawing on the board and tell the pupils that forests are structured in layers.
2. On the board, draw an outline of a multistorey house around your forest drawing (see Figure 1.1), as shown in Figure 1.2.
3. **Explain:** The different heights of plants create layers in a forest – similar to the floors of a large building. Each floor or layer is home to different kinds of organisms. Some animals, such as monkeys and leopards, may move between the layers, and others may live in only one layer.
4. Draw the four forest layers (as shown in Figure 1.2) one at a time.
5. Choose four pupils to stand at the front of the class and divide between them the manila cards you have prepared. Ask the pupils to stick the cards with the names of the animals or other organisms in the correct places on the board when you mention them (as you read out the text below).

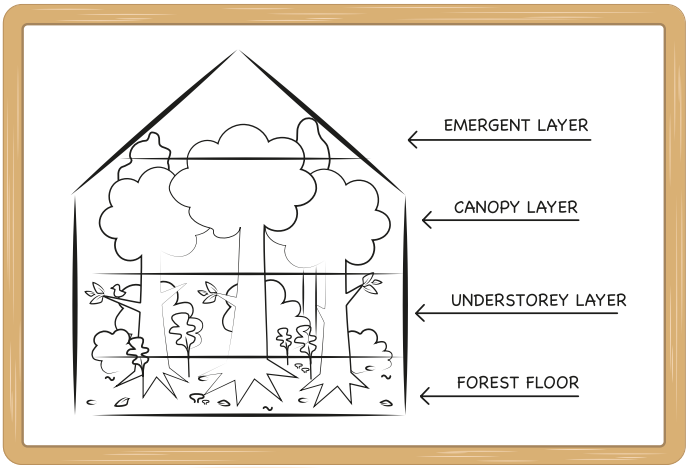


Figure 1.2. The four forest layers

6. Tell the pupils that if an animal is mentioned twice they should move the animal's card to the border between the two layers. Ask the rest of the class to call out if the four pupils forget to move a card.
7. After you write each canopy layer in the appropriate place on the board, read to the pupils the following text (the animals in bold are those written on the manila cards):
   - The **forest floor** (or "ground level") comprises the soil as well as fallen leaves, bark and branches, and other dead plant matter (called "litter" and also "humus"). This is where the roots of forest plants and trees grow. Various organisms live in forest soils and litter, such as fungi, ants, beetles, spiders and **earthworms**. These and other organisms break down dead plants and animals, which helps create and enrich the soil. Forest animals living on the forest floor may include mammals such as lions, **elephants**, deer, rats and mice, and amphibians such as frogs.
   - The **understorey** is a dark, cool and often moist environment above the forest floor under the branches of the taller trees. Many plants grow in this layer, such as mosses, ferns, shrubs and tree saplings. The trunks of the tall trees pass through this layer and their canopies provide shade for the understorey. The understorey may be home to animals such as snakes, **lizards**, frogs, **tree frogs**, spiders, beetles and ants. Monkeys, gorillas and **leopards** may spend parts of their lives in forest understoreys.
   - The **canopy** consists of the upper branches and leaves of the taller trees (called their crowns). This layer provides the understorey and the forest floor with shade and protection from wind and the impacts of raindrops. Insects such as bees, ants, beetles and **butterflies** may live in forest canopies. These provide sources of food for canopy-feeding birds as well as for reptiles such as snakes, **lizards** and chameleons, and amphibians such as **tree frogs**. **Bats**, monkeys and **leopards** may live in or use the canopy layer. Some plants, such as orchids, mosses, ferns and lichens, grow on tree trunks and branches high above the ground.
   - The **emergent layer** is formed by the very tallest trees in the forest, which stick out above the main forest canopy. The emergent layer may be home to hawks, **eagles**, **butterflies**, **bats** and monkeys.

3 Activity 3: Note results

indoor

This activity should take **15 minutes**.

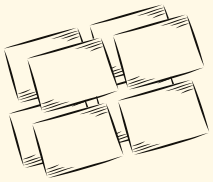
1. Ask the pupils to look at the drawing on the board. Ask them to suggest two more examples of organisms that might live in each forest layer, based on your explanation in the previous activity. Write their answers on the board next to the appropriate forest layer.
2. Ask the pupils to copy the drawing into their exercise books, including the names of the forest layers and the organisms associated with them.

LESSON 2

Create a forest layers memory game

2

Required materials



MANILA CARDS
(1 per pupil)

Preparation for the lesson

Draw the picture from the last lesson (Figure 1.2) on the board.

1 Activity 1: Repeat what you learned

indoor

This activity should take **5 minutes**.

1. Point to the picture on the board and ask the pupils to refer to the drawings in their pupils' books from the previous lesson. Repeat the key points from the last lesson:
   - Forests may have several layers: a floor, an understorey, a canopy and an emergent layer.
   - Each layer is home to different types of organisms, which, together, comprise the biodiversity of the forest. Many animals live in forests. Some move between layers, and others live in only one layer. Not all forests have all four layers.
2. Tell the pupils they will now deepen their knowledge by creating a memory game.

2 Activity 2: Create a memory game

indoor

This activity should take **35 minutes.**

1. Organize the class into groups of eight to ten pupils and hand a manila card to each pupil.
2. Ask each group to further divide into pairs (so there will be four to five pairs of pupils in each group).
3. Assign each pair in a group to work on one of the forest layers:
   - forest floor
   - understorey
   - canopy
   - emergent layer

> **Note:** If a group has five pairs, assign the fifth pair to any one of the four layers.

4. Tell each pair to draw, on two cards, a single forest organism of their choosing that lives in their assigned forest layer. For example, a pair assigned to the canopy might draw (on both cards) a butterfly, and a pair assigned to the understorey might draw a fern. Make sure that the two cards have the same organism because they will later be used in the memory game, in which the players will need to find matching pairs.
5. Collect the memory cards at the end of the lesson, making sure that each group's memory cards representing the four forest layers are kept together.
6. If there is time left and all pupils have drawn their memory cards, you can explain the rules of the memory game that will be played in the next lesson.

LESSON 3

Play a forest layers memory game

3

1 Activity 1: Recognize and pair forest animals

indoor

This activity should take **25 minutes.**

1. Explain the rules of the memory game to the class, as follows:
   - **a.** The class will form the same groups as in the previous lesson. All groups will play the memory game simultaneously using one of the packs of memory cards created in the previous lesson.

     Note: Each group should have four to five pairs of cards.

   - **b.** Each group will shuffle a pack of memory cards and then place the cards face down on the floor or a table, arranged randomly. The task is to match the correct pairs.
   - **c.** To play the game, the group will form pairs, with each pair competing against the others.
   - **d.** To start the game, a pair of pupils will turn over two random cards. If the cards match, they will be put aside and the two pupils will earn a point. The group will briefly discuss the forest layer in which the organism in the drawing lives.
   - **e.** If the cards do not match, the cards will be turned face-down again in the same place.
   - **f.** Then, another pair of pupils will start at step **c**. As the game goes on, the challenge will be to remember the locations of the various organisms so that if (for example), you turn over a butterfly, you will be able to correctly choose its pair from the remaining cards.
   - **g.** The game continues until all the memory cards have been matched. The pair of pupils with the most matching pairs (and thus the highest number of points) wins.

2. Instruct the pupils to form their groups and pairs from the previous lesson and start the game by following steps **b** to **e**.
3. After each game, the groups should swap their card sets with other groups, shuffle the cards thoroughly and repeat steps **c** to **f**. The activity continues in this way until the end of the lesson.

2 Activity 2: Match animals and forest layers

indoor

This activity should take **15 minutes**.

1. Write the two columns shown in Figure 1.3 on the board.

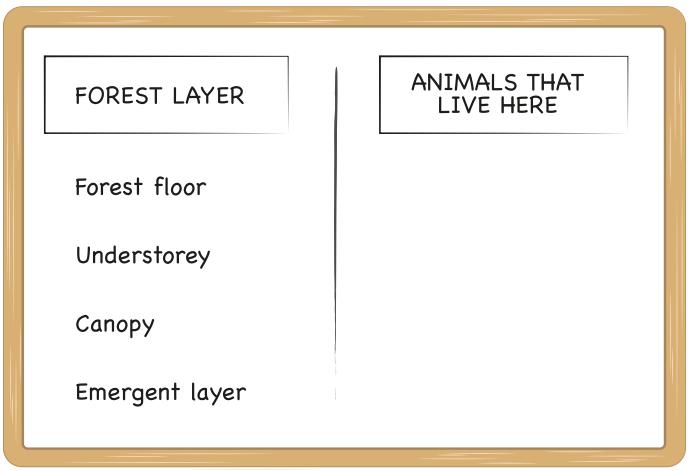


Figure 1.3. The forest layers

2. Ask a pupil to name an organism from the memory game.
3. Ask another pupil to name the forest layer in which that organism lives. Write the name of the organism in the corresponding layer on the board.
4. Ask other pupils the same thing until there are four to five examples in each forest layer (Figure 1.4). Possible answers include:
   - Forest floor – earthworms, ants, termites, beetles, rats, mice, elephants, lions, antelopes and deer.
   - Understorey – ferns, mosses, snakes, lizards, frogs, tree frogs, mice, beetles, ants, spiders, monkeys, gorillas and leopards.
   - Canopy – bees, ants, beetles, butterflies, snakes, lizards, chameleons, bats, monkeys, leopards, tree frogs.
   - Emergent layer – hawks, eagles, bats, butterflies, monkeys and snakes.

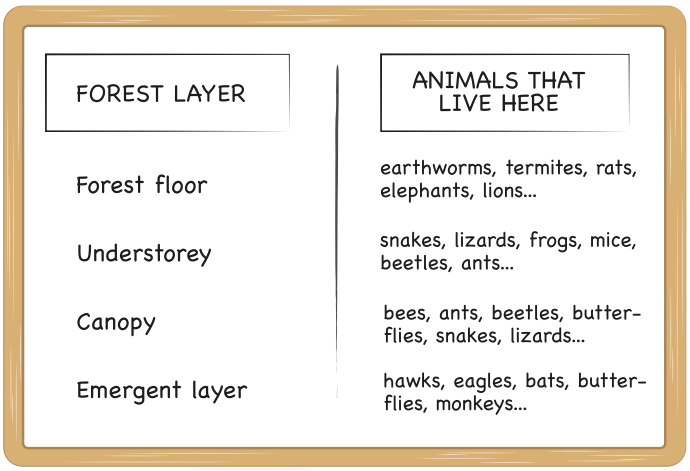


Figure 1.4. The forest layers, and the names of animals that live in them

5. Ask the pupils to copy the two columns into their exercise books.

Preparation for the next lesson

Tell the pupils that, in the next lesson, they will learn more about trees. Ask them to look at real trees on their way back home. Ask the following questions to help them notice certain features:

- What does the tree bark look like? What colour is it? What is its texture (is it rough or smooth)?
- What do the leaves look like? What is their shape (e.g. jagged, round or pointed) and colour?
- Does the tree have flowers? If so, what is their size, shape and colour?
- Does the tree have fruit? If so, what is their size, shape and colour?

Notes

[1] **FAO**. 2020. *Global Forest Resources Assessment 2020 – Main report.* Rome. https://doi.org/10.4060/ca9825en

[2] **Botanic Gardens Conservation International**. 2021. *State of the world's trees.* Richmond, UK.

[3] **Vié, J.C., Hilton-Taylor, C. & Stuart, S.N., eds.** 2009. *Wildlife in a changing world: an analysis of the 2008 IUCN Red List of threatened species.* IUCN.

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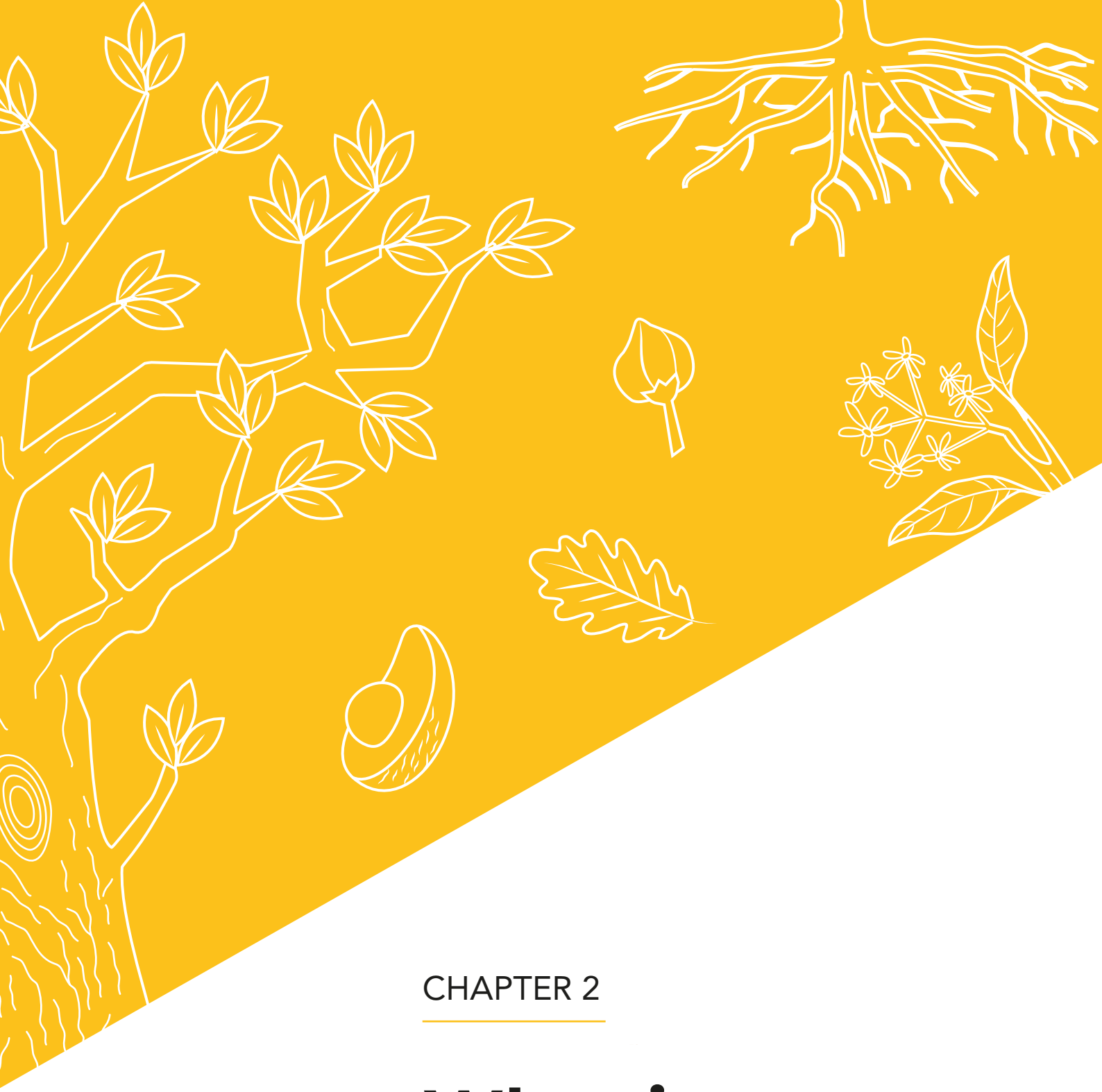


CHAPTER 2

What is a tree?

Overview

In this chapter, the pupils will learn the main parts of a tree and their functions through a drawing exercise and an outdoor game. They will also learn the names and characteristics of four of the most common forest trees in the United Republic of Tanzania through a matching exercise. The pupils will plant a seed in a pot and observe the plant as it grows to gain an understanding of the importance of tree nurseries for sustainable forestry.

Objectives

By the end of the chapter, the pupils will be able to:

- describe the individual parts of a tree and their functions;
- name and recognize four of the most common tree species in the United Republic of Tanzania; and
- understand the uses and benefits of tree nurseries.

Background information

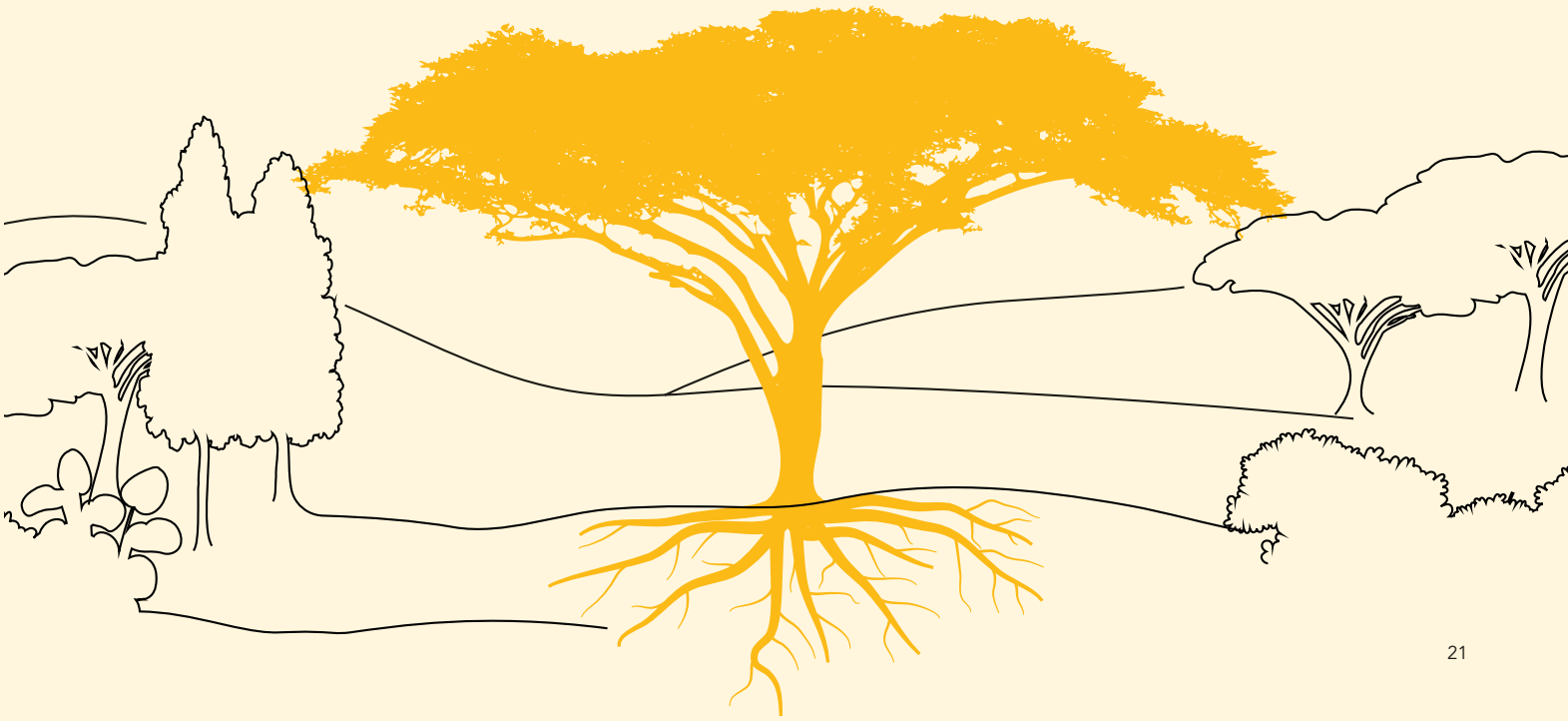
What is a tree made of?

Trees are the largest plants on Earth. They can live for centuries and even thousands of years – some individual trees are believed to be almost 5 000 years old.

The world contains more than 60 000 tree species.[1] It is possible to distinguish tree species by the appearance of their leaves, buds, flowers, fruit and bark, as well as by other characteristics.

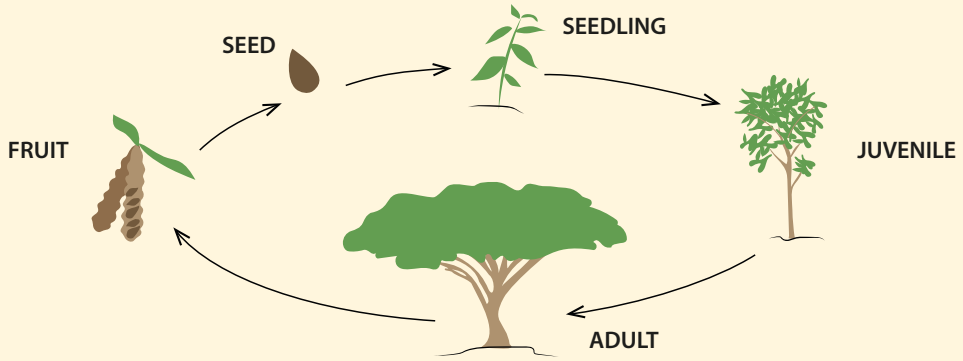
All trees have three main parts: the roots; the trunk; and the crown. Each of these plays a part in enabling trees to use sunlight, water, gases in the air and nutrients in the soil to survive, grow and reproduce.

- **Roots.** The roots support the tree and anchor it in the soil. Roots also absorb water and nutrients from the soil.
- **Trunk.** The trunk (or stem) connects the roots to the crown. The trunk has several internal layers:
  - Heartwood – the inner part of the trunk. It is older and harder than the other layers, and its role is to strengthen the trunk.
  - Sapwood – the younger part of the trunk. It contains long, thin cells called xylem, which carry water and nutrients up from the roots to the top of the tree, as well as other long, thin cells called phloem, which transport sugar manufactured by the leaves (in a process called photosynthesis) to all parts of the tree.
  - Cambium – a thin layer where new wood is produced.
  - Bark – the outer layer of the trunk, which helps protect the cambium.
- **Crown.** The crown comprises the tree branches and leaves in the upper part of the tree. The branches support the leaves and expose them to sunlight. Like the trunk, branches contain supply lines that carry water, nutrients and sugar. When exposed to sunlight, the leaves produce sugar through photosynthesis; the tree uses this sugar to live and grow. Photosynthesis combines carbon dioxide from the air with water brought up from the roots to make sugar and oxygen (the oxygen is released into the air, where it is available to support other forms of life). The crown also bears flowers , which when pollinated, develop into fruit or nuts.



How do trees reproduce and what role do tree nurseries play?

Trees make fruit that contain seeds. When seeds germinate, they grow into other trees. Some of the largest trees in the world started life as small seeds from the fruit of their "mother" trees. Some trees can also replicate themselves through a process called vegetative propagation. For example, a new tree can grow from sprouts, or "suckers", which arise from special buds on the parent tree's roots and trunk.



Picture 2.1. Tree life cycle

Forests composed mainly of trees that have grown naturally from seeds or suckers are known as naturally regenerated forests. Forests in which all or most of the trees have been planted by people are called planted forests.[2] Usually, establishing a planted forest involves raising seedlings in a nursery and planting them in an open area to replace trees that were recently harvested or burnt (reforestation) or to create a new forest (afforestation). Worldwide, 93 percent of the forest area is composed of naturally regenerated forests and 7 percent is planted.[3]

Naturally regenerated forests. In forests, the wind and birds and other animals can spread tree seeds. If a seed falls on the ground and gets enough light, water and nutrients, it will sprout into a seedling, grow into a sapling and eventually become a mature tree. When left undisturbed, most trees will continue growing for decades and some for centuries.

Planted forests. Tree nurseries produce seedlings of trees and other plants for various purposes. For example, seedlings can be planted to rehabilitate damaged or harvested forests and to establish forests where there was previously no tree cover. Producing tree seedlings (young trees) is important for growing healthy and productive planted forests. Typically, in a nursery, seeds of the desired forest species are planted in a "potting mix" – a special soil – and watered regularly until the seeds germinate to become seedlings. When they reach a certain size, the seedlings are planted out in the field. In the United Republic of Tanzania, seedlings are raised in two types of containers – tubes in plastic such as polythene, and seedling trays. Plastic tubes are discouraged because they can be an environmental hazard (such as by causing pollution in waterways). Seedling trays are preferred because they can be reused and are easy to handle.

Picture 2.2. Worker watering tree seedlings in a nursery

Picture 2.3. Pine tree seedlings in a tree nursery

What are the main tree species in the United Republic of Tanzania?

It is estimated that there are more than 3 trillion trees in the world.[4] The United Republic of Tanzania is home to 77 billion trees,[5] of which four species are very common, accounting for 8.5 billion trees (about 11 in every 100 trees in the country). The four species are:

1. Large-fruited bushwillow (*mlama*)
2. Horn-pod tree/wild rubber (*mtogo*)
3. Bean-pod tree (*myombo*)
4. Velvet bushwillow (*msana*)

Picture 2.4. Large-fruited bushwillow

Picture 2.5. Horn-pod tree/wild rubber

Picture 2.6. Bean-pod tree

Picture 2.7. Velvet bushwillow

Other common tree species in the United Republic of Tanzania are:

- mango
- acacia
- baobab
- jackfruit

Pictures of these eight species and their flowers, leaves and seed pods are available at the end of the chapter.

LESSON 4

What makes a tree?

4

1 Activity 1: Share observations from homework

indoor

This activity should take **15 minutes**.

1. Write the words bark, leaves, flowers and fruit on the board.
2. Remind the pupils of their homework from the previous chapter, which was to observe, draw and describe a tree. Point to the words on the board ("bark", "leaves", "flowers" and "fruit") and remind the pupils about what they were asked to observe.
   - What did the tree bark look like? What colour was it? What was its texture (was it rough or smooth)?
   - What did the leaves look like? What was their shape (e.g. jagged, round or pointed) and colour?
   - Did the tree have flowers? If so, what was their shape and colour?
   - Did the tree have fruit? If so, what was their shape and colour?
3. Ask four to six pupils to volunteer what they observed from studying their trees. Ask the pupils to tell the class where they found the tree they are describing.
4. Ask the class what they notice when they hear the observations of the pupils.
5. **Explain:** Trees can look very different – for example, they can have different kinds of bark and leaves. Different trees might blossom and bear fruit at different times.

2 Activity 2: Draw the parts of a tree

indoor

This activity should take **25 minutes**.

1. Refer to the trees the pupils observed and discussed in Activity 1. Ask them to think of characteristics shared by all trees.
2. Ask them the following questions. Let the pupils answer first before providing the correct answers (if needed).
   - What does every tree have that you usually can't see because they are in the ground?
   - » **Answer:** Roots.

- ► What is the function of the roots?
- » **Answer:** They anchor the tree in the soil to keep it steady.
- » **Answer:** They absorb nutrients and water from the soil.

3. Draw the roots of a tree at the bottom of the board (Figure 2.1).

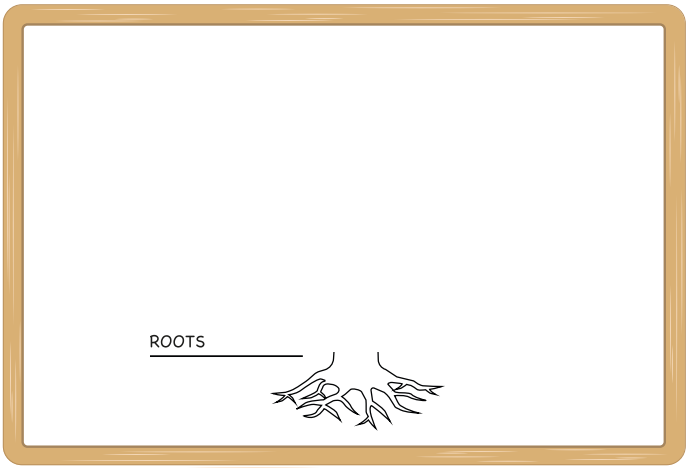


Figure 2.1. Tree roots

4. Now ask them the following questions:
   - ► What does every tree have that connects directly to the roots above the ground?
   - » **Answer:** A trunk (also called a stem).
   - ► What is the function of the trunk?
   - » **Answer:** Water and nutrients are transported up along "supply lines" inside the trunk to the branches and leaves.
   - » **Answer:** The trunk is made of wood and supports the branches and leaves.

5. Draw a trunk on the board by connecting it to the roots (Figure 2.2).

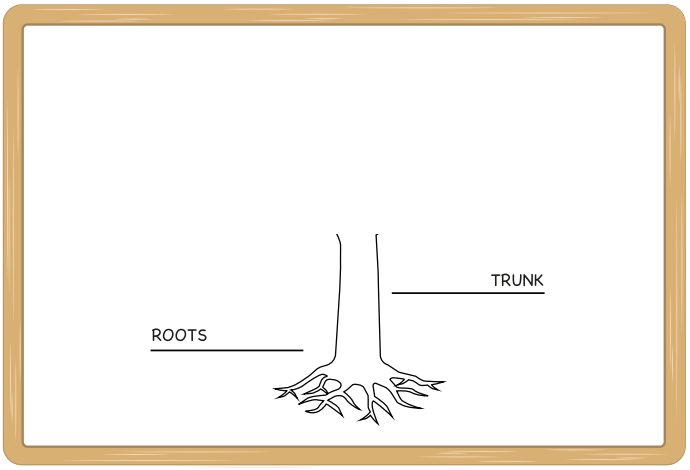


Figure 2.2. Tree roots and trunk

6. Then ask the following questions:
   - ► What is the name of the top part of a tree?
   - » **Answer:** Crown.
   - ► What are the elements of the crown?
   - » **Answer:** Branches and leaves.
7. Add thick and thin branches to the drawing (Figure 2.3).

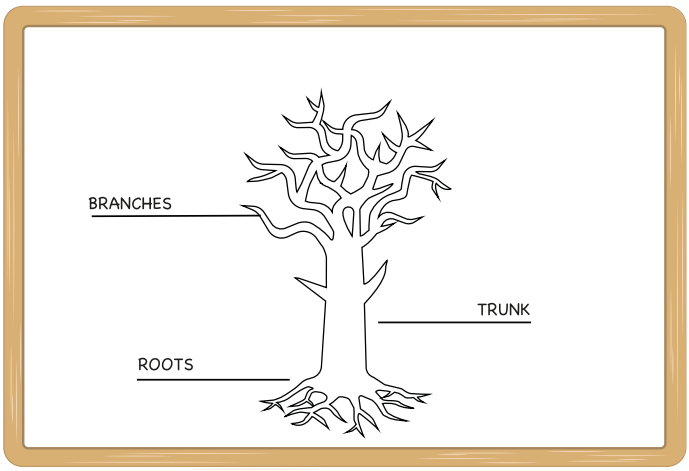


Figure 2.3. Tree roots, trunk and branches

8. **Explain:** Like the trunk, branches contain supply lines that carry water and nutrients to the top of the tree. Other supply lines carry food produced by the leaves to other parts of the tree.
9. Add the leaves to the drawing (Figure 2.4).

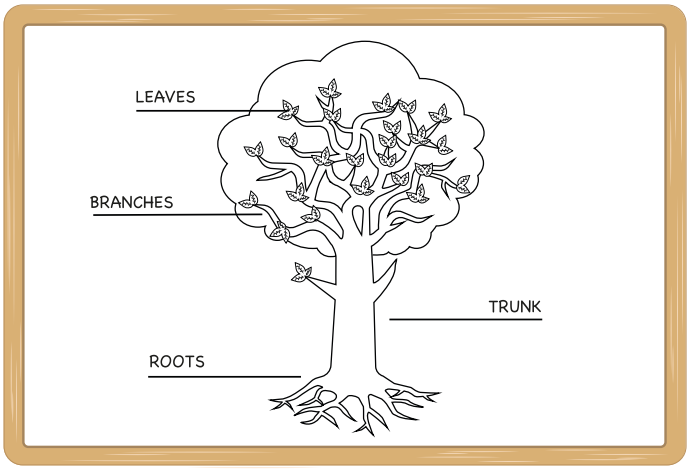


Figure 2.4. Tree roots, trunk, branches and leaves

10. **Explain:** Leaves are the "power plant" of the tree where it produces food using energy from the sun.
11. Add flowers and fruit to the drawing (Figure 2.5).

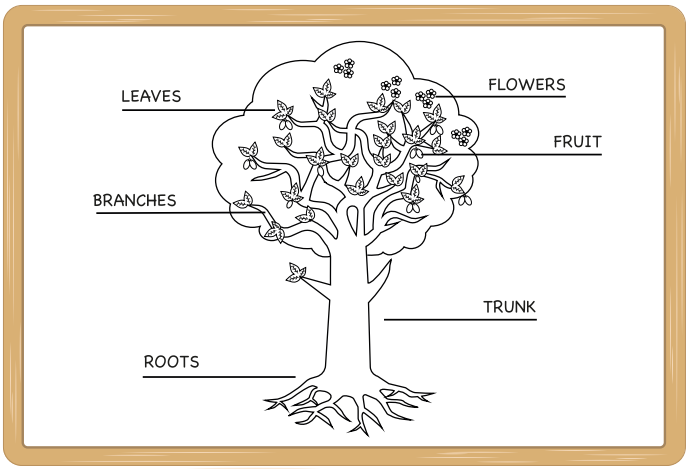


Figure 2.5. The parts of a tree

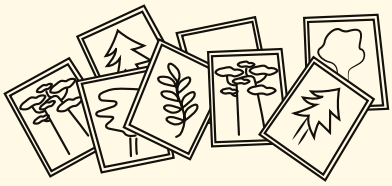
12. **Explain:** Flowers and fruit – flowers on trees are pollinated and develop into fruit or nuts. This is how trees reproduce. The leaves, flowers and fruit grow on thick and thin branches (thin branches are sometimes called twigs).
13. Ask the pupils to copy the drawing into their exercise books.

LESSON 5

Create the living picture of a tree

5

Required materials



8 PICTURES OF TREES AND THEIR PARTS

1 PAIR OF SCISSORS
TO CUT OUT THE PICTURES

Preparation for the lesson

Cut out the sheets included at the end of this chapter. Each contains the photos of the parts of a tree species. These sheets will be used in Activity 1. If the pupils have their pupils' books, they will find the pictures there, and there is no need to cut the sheets out of this book.

1 Activity 1: Create a living picture of a tree

indoor outdoor

This activity should take **30 minutes**.

In this game, the pupils will use role-play and movement to convey aspects of trees to other pupils without speaking. The species are:

- large-fruited bushwillow
- horn-pod tree/wild rubber
- bean-pod tree
- velvet bushwillow
- baobab
- acacia
- mango
- jackfruit

Inside

1. Ask the pupils to name trees they know are found in the United Republic of Tanzania.
2. Write the names of these trees on the board.
3. Check that the eight species named above are among the answers written on the board. If not, add them to the list and tell the pupils that these trees are common in the United Republic of Tanzania.
4. Mark each of the eight species with an asterisk (to differentiate them from the others) and tell the pupils that they will learn more about these trees in this lesson.
5. Show the pictures of the eight trees, one after the other, and ask the class to name them from the list on the board. If the pupils have their pupils' books, tell them they can find the same pictures there.
6. Organize the class into four equal-sized groups.
7. Ask each group to split into two subgroups, A and B.
8. Give each subgroup a tree picture. They should not show this picture to the other subgroup or tell them the name of their tree.
9. Tell the pupils that they will soon go outside. When outside, each subgroup will discuss the characteristics of their tree, such as its size and shape, the colour of its flowers, and the shape of its fruit and leaves. They will then find a way to make a "living picture" of their tree, which the other subgroup will try to guess. They will make the living picture using their own bodies (e.g. a baobab is big, and fat around the middle; an acacia is small, with a spreading crown) and role-play. Ensure that the pupils know they will not be able to use their voices. The other subgroup will try to guess the name of the tree.
10. Now, take the pupils outside to discuss their trees in their subgroups and decide how to create a living picture of their tree.

Outside

11. Give the subgroups about 5 minutes to discuss their trees and decide how to create their living pictures by forming a tree with roots, a trunk and a crown.
12. The groups will then come back together and, in each group, subgroup A will create its living picture for subgroup B, which will try to guess the name of the tree.

Tip: The pupils can create living pictures of trees in many ways, and it is likely that they will show incredible creativity. Here is one potential way: one pupil stands in the middle (forming the wood of the trunk); two or three pupils form a circle around the wood to mime the protective bark (if the tree is the baobab, the trunk could be made thicker to represent the particularly thick trunk of the baobab). The pupils in the "crown" hold pieces of cloth or fallen leaves to represent the tree's leaves, flowers or fruit, waving them back and forth to symbolize the wind in the treetop. Some pupils mime picking fruit from a branch or a bird flying around the tree. Some pupils lie on the ground and spread their arms and legs to symbolize the branching root system. This is a living picture (or sculpture) of a tree. The pupils in the other subgroup will try to guess the name of the tree.

13. Subgroup B is allowed only two chances to guess the name of the tree. If the pupils have their pupils' books, tell them they may use these to check the features of the eight trees and help them guess.
14. Assist the groups, as needed.
15. When subgroup B has made its two guesses, it will then create its own living picture for subgroup A, which will try to guess the name of the tree in the same way. When all the subgroups have made their guesses, go to the next activity.

2 Activity 2: Repeat the parts of a tree and their functions

outdoor

This activity should take **10 minutes**.

1. Tell the pupils to sit on the ground.
2. Ask them what they found difficult and what they found easy about the previous activity.
3. Ask the pupils about the different parts of a tree and why they are important, as follows.

   ► Why do trees need roots?

   » **Answer:** The roots support the tree and anchor it in the soil. They also absorb water and nutrients from the soil, which the tree uses to survive, grow and reproduce.

   ► What is the tree trunk for?

   » **Answer:** The trunk supports the crown, so it must be strong. The bark on the trunk protects it from fire and insect attack and reduces water loss. Water and nutrients absorbed by the roots travel up through the trunk to the crown, and food manufactured by the leaves travels to all parts of the tree, including the trunk and, via the trunk, to the roots.

   ► Why do trees need crowns?

   » **Answer:** The crown consists of thick and thin branches, leaves, flowers and fruit. The leaves are tiny factories that make sugar using water and a gas (called carbon dioxide) from the air, with sunlight supplying the energy. This process is called photosynthesis, and the whole tree uses the manufactured sugar to survive and grow. The tree's fruit and seeds are produced in the crown.

4. Conclude by reading the correct answers above.

LESSON 6

Plant a class tree

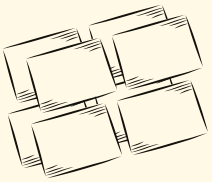
6

Required materials

SEVERAL SEEDS FROM A TREE
or another readily available plant
(e.g. bean)

1 POT WITH SOIL

WATER



MANILA CARDS
(1 per pupil)

Preparation for the lesson

On the board, copy Figure 2.6, including the tree names and labels A, B, C, D, E, F, G, H and I.

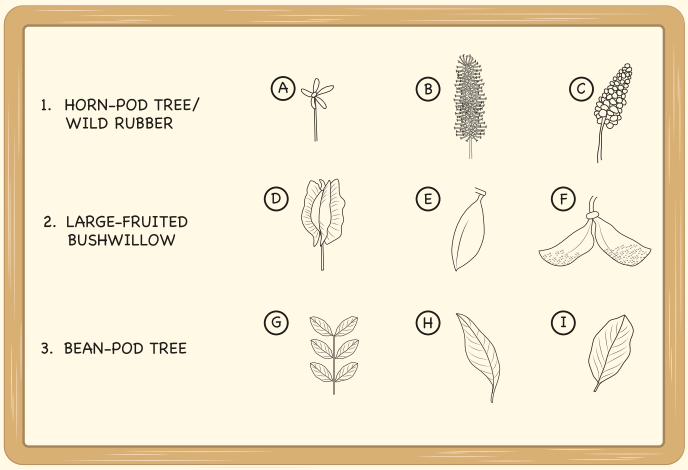


Figure 2.6. Three tree species and their flowers, leaves and seed pods, arranged randomly

1 Activity 1: Get to know Tanzanian tree species

indoor

This activity should take **15 minutes**.

1. Remind the pupils about what they learned previously – all trees have the same basic parts, which may look different in different species of tree.
2. Point out to the pupils that the names of four trees commonly found in the United Republic of Tanzania are written on the board. They already know some things about these trees, which they learned in the previous lesson. Various leaves, flowers and fruit are also drawn on the board, but they are not arranged according to the trees to which they belong. Tell the pupils that their task will be to match the trees with the correct leaves, fruit and flowers.
3. Organize the class into three or more equal-sized groups.
4. Tell the pupils they should discuss the task in their groups and then write their answers in their exercise books. They can do this by first writing the name of the tree and then the letters corresponding to what they think are its leaves, flowers and fruit. For example: "Horn-pod tree: leaves = A, flower = G, fruit = E". Allow 10 minutes for the groups to complete the task.
5. Then, reveal the answers by writing the number corresponding to the correct tree next to each tree part (Figure 2.7).

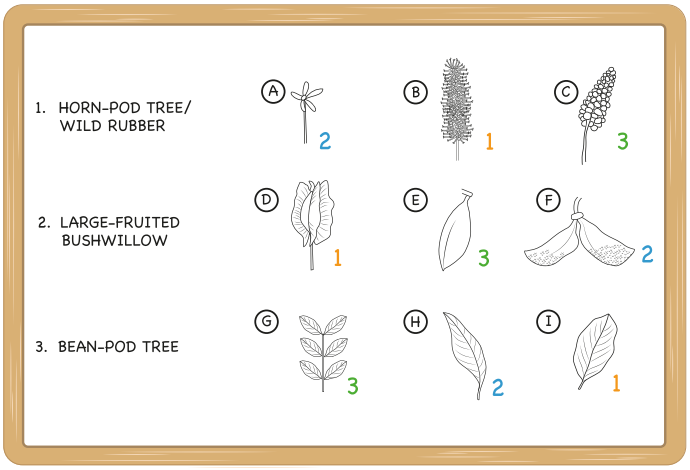


Figure 2.7. Flowers, seed pods and leaves of three trees

6. Ask each group to tally the number of correct answers. The group with the most correct answers wins.
7. Ask the pupils to copy the drawings into their exercise books, including the numbers showing the correct answers.

2 Activity 2: Plant a tree

indoor

This activity should take **15 minutes**.

1. Tell the pupils that even the tallest and widest trees started as tiny seeds.
2. Show the pupils the seeds you brought into the class. Pass some around so that the pupils can see them closely and touch them.
3. Ask one pupil to place soil in a pot and ask another to put two to three seeds on top of the soil and cover them with a small amount of soil. Ask a third pupil to gently pour water onto the soil.
4. Tell the pupils that they have now planted some seeds and that the class must take care of the pot. This means that the pupils will need to water it from time to time – but not too much, so that the seeds do not rot. They will also need to ensure that the pot receives enough sunlight but does not get too hot or too dry.
5. Tell the pupils that they planted three seeds in case one or two don't germinate. If more than one seedling emerges, they can transplant the extra ones to other pots.
6. Tell the pupils it will take time for the seeds to sprout. Ask them to record, in their exercise books, the date on which the seeds were planted so that they can calculate how long it takes before the seedling emerges from the soil. Over time, the pupils will observe how a seed becomes a seedling that can be planted outside and then how it grows to become a sapling.
7. Tell the pupils you will find a suitable place for the pot at the end of the lesson.

> **Note:** If you cannot obtain tree seeds, use other, easily available seeds (e.g. bean seeds). If you do, explain to the pupils that trees also grow from seeds, just like the plant they just sowed.

3 Activity 3: Learn what tree nurseries are

indoor

This activity should take **10 minutes**.

1. First, ask the pupils where they think the trees in forests come from. Invite a few pupils to volunteer their ideas.
2. **Explain:** In forests, the wind, as well as birds and other animals, help spread seeds. On the ground, some of these seeds germinate and eventually grow into saplings. People can help forests regrow by sowing seeds in nurseries, raising seedlings and planting them in the forest. Forests composed by trees that mostly have been planted by people are called planted forests.

3. **Explain:**
   - Producing tree seedlings (young trees) is important for growing healthy and productive planted forests.
   - Seedlings grown in nurseries can be used to add more trees to existing forests and to create new forests.
   - Two types of containers are used to grow seedlings in tree nurseries in the United Republic of Tanzania: tubes made of plastic (e.g. polythene) and seedling trays (show the photos below to the pupils or tell them to look at the photos in their pupils' books). The use of plastic tubes is discouraged because the plastic is used only once and then becomes litter. Seedling trays are preferred because they can be reused and are easy to handle.
4. With the pupils, find a suitable place in the classroom for the pot they planted in the previous activity, where the seedling is likely to grow well and where the pupils will be able to observe its progress. In the next few days and weeks, check the pot regularly with the pupils.

1. Large-fruited bushwillow (*mlama*)

Picture 2.8. Large-fruited bushwillow tree

Picture 2.9. Large-fruited bushwillow leaves

Picture 2.10. Large-fruited bushwillow flower

Picture 2.11. Large-fruited bushwillow fruit

2. Horn-pod tree/wild rubber (*mtogo*)

Picture 2.12. Horn-pod tree

Picture 2.13. Horn-pod leaves

Picture 2.14. Horn-pod flower

Picture 2.15. Horn-pod fruit

3. Bean-pod tree (*myombo*)

Picture 2.16. Bean-pod tree

Picture 2.17. Bean-pod leaves

Picture 2.18. Bean-pod flower

Picture 2.19. Bean-pod fruit

4. Velvet bushwillow (*msana*)

Picture 2.20. Velvet bushwillow tree

Picture 2.21. Velvet bushwillow leaves

Picture 2.22. Velvet bushwillow flower

Picture 2.23. Velvet bushwillow fruit

5. Baobab

Picture 2.24. Baobab tree

Picture 2.25. Baobab leaves

Picture 2.26. Baobab flower

Picture 2.27. Baobab fruit

6. Acacia

Picture 2.28. Acacia tree

Picture 2.29. Acacia leaves

Picture 2.30. Acacia flower

Picture 2.31. Acacia fruit

7. Mango

Picture 2.32. Mango tree

Picture 2.33. Mango leaves

Picture 2.34. Mango flower

Picture 2.35. Mango fruit

8. Jackfruit

Picture 2.36. Jackfruit tree

Picture 2.37. Jackfruit leaves

Picture 2.38. Jackfruit flower

Picture 2.39. Jackfruit fruit

Notes

[1] **Beech, E., Rivers, M., Oldfield, S. & Smith, P.P.** 2017. GlobalTreeSearch: The first complete global database of tree species and country distributions. *Journal of Sustainable Forestry*, 36(5): 454–489. https://doi.org/10.1080/10549811.2017.1310049

[2] **FAO**. 2018. *Terms and definitions – FRA 2020*. Forest Resources Assessment Working Paper 18. Rome. www.fao.org/3/I8661EN/i8661en.pdf

[3] **FAO**. 2020. *Global Forest Resources Assessment 2020 – Main report*. Rome. https://doi.org/10.4060/ca9825en

[4] **Crowther, T.W., Glick, H.B., Covey, K.R., Bettigole, C., Maynard, D.S., Thomas, S.M., Smith, J.R. *et al.*** 2015. Mapping tree density at a global scale. *Nature*, 525(7568): 201–205. https://doi.org/10.1038/nature1496

[5] **Ministry of Natural Resources and Tourism**. 2015. *National Forest Resources Monitoring and Assessment (NAFORMA) main results.* Dar es Salaam.

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CHAPTER 3

Forests and soil

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Overview

In this chapter, the pupils will learn about the components of soils and the functions of soils in ecosystems, and they will understand the roles of soils in our lives. The pupils will make their own soil profiles and identify the various soil layers. They will observe the importance of vegetation cover for reducing soil erosion and increasing soil stability.

Objectives

By the end of the chapter, the pupils will be able to:

- describe the components of soil and its layers;
- describe how soil is formed;
- understand the importance of soil for forests, ecosystems and people; and
- understand the importance of forests for soil.

Background information

What is soil made of and how is it formed?

Soil is the top layer of the Earth's surface in which plants have their roots. It results from the decomposition of:

- **Inorganic materials** – the non-living components of the soil, such as sand, clay and silt.
- **Organic matter** – dead things in various states of decomposition, such as animals, wood, leaves, twigs and roots. These organisms break down over time and form a rich, dark-coloured material called humus.

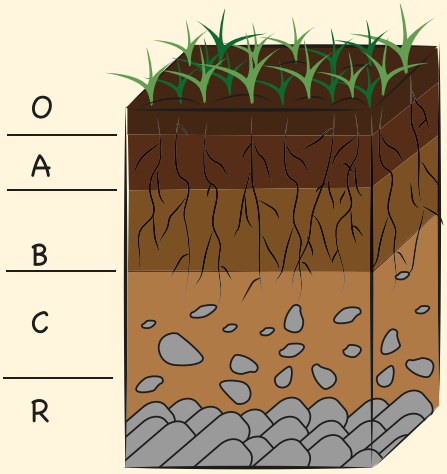
The average soil is composed of the following: inorganic materials (45 percent); air (25 percent), which occupies spaces called pores between the inorganic materials; water (25 percent), which seeps into the soil through pores and channels; and humus (5 percent) created by the decomposition of plant and animal matter.

Soil formation is a complex and very slow process – it takes over 1 000 years to make just 1 cm (centimetre) of soil.[1] Numerous environmental factors help determine the type of soil that forms, such as the nature of the bedrock, the plant and animal species present, the slope of the land, rainfall and the range of temperatures. The "story" of a soil can be read in its profile.

Soil profile

Soil is organized in a series of layers called horizons. These layers are composed of inorganic materials, organic matter, air and water. The sequence of horizons is called the soil profile. Most soil profiles have the following horizons:

- **Humus (O).** Humus is a dark-coloured substance comprising organic matter such as decomposing leaves (litter). Humus contains nutrients essential for the growth of plants and the many living beings in the soil (e.g. earthworms). Humus can be deep, shallow or absent.
- **Topsoil (A).** Immediately below the humus is the topsoil, which is often dark, soft and porous. Topsoil contains a large amount of organic and inorganic material and is often the most fertile layer of the soil, which makes it a good medium for plants to grow in. It contains many soil-dwelling animals, such as earthworms, insects and microorganisms.
- **Subsoil (B).** This layer below the topsoil is usually lighter in colour because it contains less organic matter. It is often harder and more compact and contains few soil-dwelling animals. Although it is less fertile than topsoil, the subsoil is rich in clay and minerals such as magnesium, iron and copper. The roots of most trees are able to reach this layer.
- **Substratum (C)**. This is the "parent" material of soils; soils begin forming in this layer, which sits between the soil and the bedrock (the R layer). The substratum is less weathered (broken down) than the upper layers and contains partially disintegrated material from the R layer.
- **Bedrock (R).** This is the mass of solid rock below the soil. It is not soil but the source rock from which the soil above is created. When it is close enough to the surface to be exposed to weathering, small fragments break off from the bedrock and form the parent material (the "substratum") from which soils begin to form. Its nature depends on the geology of the region. Only a few roots can penetrate it.



Picture 3.1. Soil profile

What is soil health and why is it important in our lives and to the environment?

Soil health can be defined as the ability of the soil to sustain the productivity, diversity and services of terrestrial ecosystems.[2] Dark-coloured, moist soil is a sign of healthy soil that is rich in humus. Healthy soils:

- **Support trees and other plants.** The roots of trees and other plants are anchored in the soil, enabling them to grow above ground with relatively little risk of falling over.
- **Provide food.** Crops need soil to grow in and thereby produce food for humans and livestock.
- **Store large amounts of water.** Soil holds water, which is crucial for maintaining food production and increasing resilience to floods and droughts.
- **Filter water.** Soil absorbs, stores and purifies water (by removing pollutants), making it available for plant growth and for humans and animals.
- **Store and break down pollutants.** Soil can break down pollutants into less harmful substances through chemical action.
- **Help combat climate change.** Soil is one of the largest storehouses of carbon on Earth, helping reduce global warming and reducing carbon dioxide (CO_2) emissions.
- **Provide materials and products for human use.** Soil provides materials for the construction of human infrastructure. Soil is mined for clay to manufacture bricks and for sand to manufacture glass.
- **Host a large amount of biodiversity.** Soils are home to more than 25 percent of the Earth's biodiversity. There are more living organisms in a handful of healthy soil than there are people on the planet. These organisms keep the soil healthy and play crucial roles in maintaining soil fertility. The more fertile the soil, the better plants grow.
- **Play a crucial role in the nutrient cycle.** Soil is one of nature's most complex ecosystems, containing a myriad of interacting organisms that contribute to various global cycles that make life on Earth possible. Soil organisms are part of the planet's recycling system, known as the "nutrient cycle", as follows:
    - » Dead plants and animals – when plants (or parts of plants, such as leaves) and animals die, they decompose on the ground to form organic matter. Often, animals eat the dead (and living) plant and animal parts and distribute them in the form of waste.

- Soil organisms – microorganisms digest the organic matter and break it down into nutrients.
- Nutrients – nutrients dissolve in water, which carries them to the roots of living plants.
- Plants – plants absorb the nutrients and use them to grow. When those plants die, they return to the soil where they decompose, and the cycle continues.

How do forests contribute to soil health?

Forests and trees make essential contributions to **soil stability**, **fertility** and **conservation** by:

- stabilizing the soil and holding it in place with their roots, helping reduce shallow landslides;
- reducing soil degradation and desertification by stabilizing soils, maintaining water and nutrient cycling, and reducing water and wind erosion;
- providing material to create new soils through the decomposition of leaves and dead tree parts and by helping break down deeper soil layers through the physical action of their roots;
- increasing the soil's capacity to store water (the roots of trees create channels in the soil, which help the soil absorb water and increase the amount of water reaching the groundwater);
- moderating soil temperatures by casting shade with their canopies;
- minimizing soil erosion by intercepting raindrops and reducing wind speed; and
- providing livelihoods to more than a billion people.

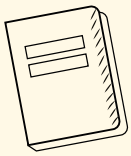
Picture 3.2. Planting mangroves for soil stabilization

LESSON 7

Why does soil matter?

7

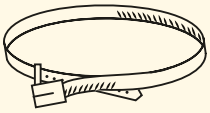
Required materials



1 BOOK

1 COTTON SOCK

1 GLASS BOTTLE



1 LEATHER BELT

1 PIECE OF FRUIT

1 VEGETABLE

1 PENCIL

SOME CORNMEAL OR FLOUR
(optional)

1 BASKET OR BOX

1 TOWEL

1 Activity 1: Learn what comes from soil

indoor

This activity[i] should take **40 minutes**.

1. Put the basket or box filled with the materials shown above in front of the class but cover it with the towel to hide the items inside.
2. Ask a pupil to come forward and reach into the basket under the towel and take out one of the objects. Let them show the object to the rest of the class. Ask the pupil to name the object.
3. Ask the pupil, "Do you need soil to produce this item?" The pupil should answer "yes" or "no" and explain their answer.

[i] This activity is adapted from www.umweltbildung.enu.at/angebot/materialien-und-methoden/boden/methode-alles-boden-oder-was

4. Continue the exercise with other pupils. As each item is removed, write the name of the object on the board and ask the pupils to copy the list into their exercise books. Explain how each item is related to soil:
   - Cotton sock – the cotton came from plants that grew in soil.
   - Book – the paper came from a tree that grew in soil.
   - Pencil – the wood came from a tree that grew in soil.
   - Glass bottle – glass is made from sand, which is part of soil.
   - Leather belt – the leather is the skin of an animal that ate grass, which grew in soil.
   - Cornmeal or flour – flour is made from maize or wheat, which grew in soil.
   - Fruit – the fruit was produced by a tree or another plant that grew in soil.
   - Vegetable – the vegetable was produced by a plant that grew in soil.

5. After all the items have been removed from the basket, **explain:** All these materials come from farms, forests or livestock. Without healthy soils, we wouldn't have any of these things.
6. Write "SOIL" in the middle of the board.
7. Ask the pupils to form pairs and to brainstorm and discuss with their partners all the benefits of soil.
8. After about five minutes, ask some of the pupils to present their results.
9. Write down the functions and benefits mentioned by the pupils on the board to create a mind map (Figure 3.1). You can provide some of the answers yourself, adding things that have not yet been mentioned.

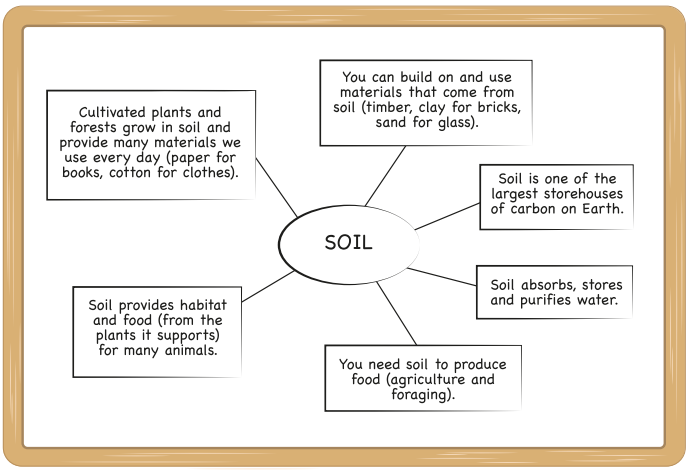


Figure 3.1. Mind map of the benefits of soil

10. Ask the pupils to copy this mind map into their exercise books.

Preparation for the next lesson

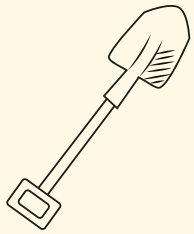
The next lesson requires preparation in advance.

LESSON 8

Make a soil profile

8

Required materials



1 SPADE
(only used by the teacher)

PAPER OR MANILA CARDS
(1 sheet for each pupils,
and 1 for the teacher)

PENCILS
(1 for each pupil)

Preparation for the lesson

- Outside the classroom: Dig four holes with a spade at least 25 cm deep in or near the schoolyard. Ensure that it is safe to dig (for example, that there are no underground pipes or cables nearby).
- Inside the classroom: Draw a soil profile (see Figure 3.2, below) on the board and cover it so that the pupils cannot see it. You will remove the cover later.

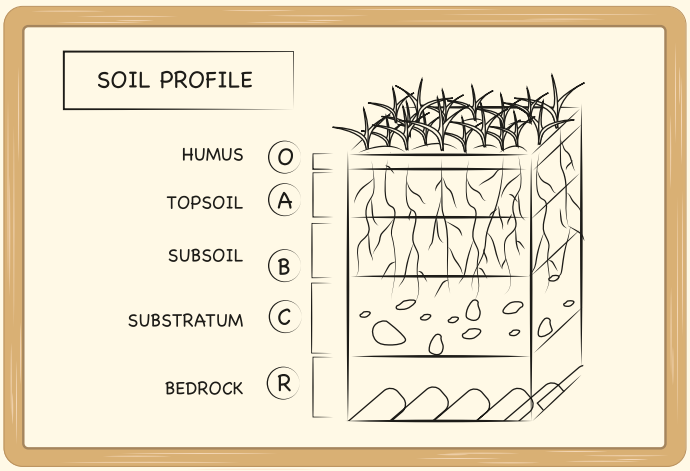


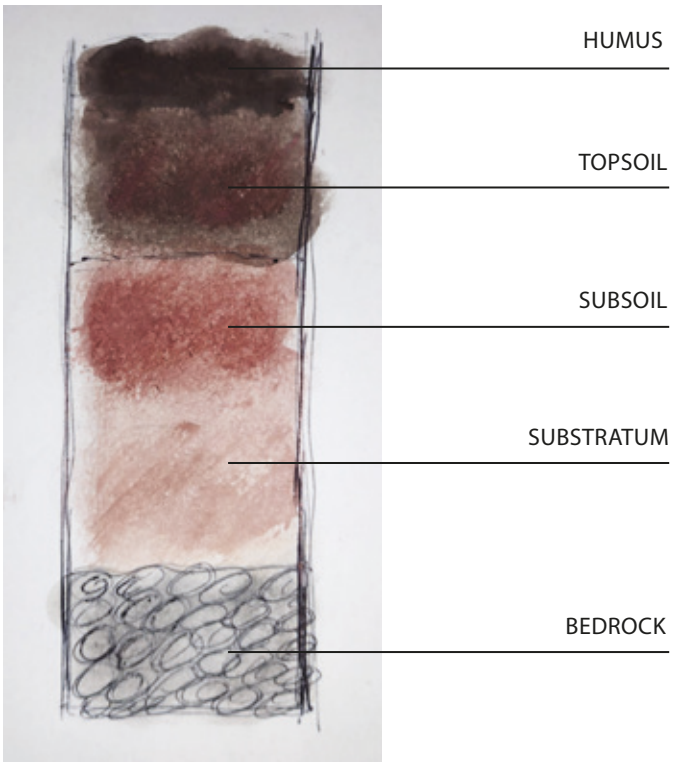
Figure 3.2. Soil profile

1 Activity 1: Make a soil profile

indoor outdoor

This activity should take **40 minutes**.

1. Tell the pupils that you have dug four holes outside.
2. Organize the pupils into four equal-sized groups and take them outside. Ask them to bring their pupils' books and exercise books with them.
3. Ask each group to stand next to one of the holes.
4. Tell the pupils that they will now reconstruct the layers of the soil, known as the soil profile, in a drawing. Show them Picture 3.3 below (it is also included in the pupils' books).
5. Ask the pupils to study the hole carefully and then draw on their manila cards or sheets of paper the various layers they see, as indicated by changes in colour and composition. Each pupil should draw their own profile. They can rest the paper on their notebooks as they draw, and they may use the dirt itself to add appropriate colours to their drawings. If the pupils see some soil organisms, such as worms or grubs, they could draw these on their profiles.
6. When the pupils have drawn their soil profiles (including the humus, topsoil, subsoil and substratum), ask them to draw another layer below the others – the bedrock layer. The pupils will need to imagine what this layer looks like because it will not be visible in the holes you dug.
7. When the pupils have finished their drawings, return to the classroom.
8. Discuss the pupils' results, using one of the pupils' drawings as an example. Here is an example of how the drawing should look:



Picture 3.3. Soil profile

9. Ask the pupils to talk about what they discovered by drawing their own soil profiles. They may say that the colour of the soil varied at different depths; they may also observe that there were fewer plant roots lower down in the soil profile.
10. **Explain:** Soil forms layers called horizons. Each horizon is different and can be distinguished by changes of colour.
11. Now uncover the board to show the soil profile you drew earlier (Figure 3.2). Discuss with the pupils the various soil horizons – what they are called and the special properties they have, as indicated below.

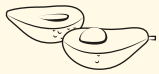
    Explain:
    - **Humus.** Explain that humus is a dark-coloured substance that mostly consists of organic matter such as decomposing leaves (litter). Humus contains a lot of nutrients essential for the growth of plants and for the life of the many animals living in soil, such as insects. It is shallow in some soils, deep in others, and sometimes completely absent.
    - **Topsoil.** The topsoil is immediately below the humus. It tends to be dark, soft and porous and is rich in nutrients. It is good material for plants and soil organisms to grow in.
    - **Subsoil.** This part of the soil has little organic matter, which is why it is usually lighter in colour than the topsoil and humus. The roots of most trees are able to reach this horizon.
    - **Substratum.** This is the horizon where soils begin forming. It is composed of broken-down rock from the bedrock.
    - **Bedrock.** This is the mass of solid rock below the soil. It is not soil but the source rock from which the soil is created. Only a few roots can penetrate it.
12. Draw a large circle around the topsoil – this horizon is particularly important for crops. It is the most fertile layer for plant growth.
13. Ask the pupils to transfer the information on the board to their own drawings of the soil profile.

LESSON 9

What is soil made of?

9

Required materials



1 AVOCADO

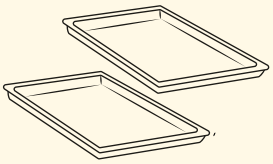
SOME DEAD LEAVES OR TWIGS IN SMALL PIECES

WATER
(enough to fill one-quarter of the glass or hand bucket)

1 GLASS OR HAND BUCKET

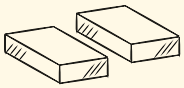
SMALL STONES
(enough to fill half the glass or hand bucket)

A MIXTURE OF SOIL
(enough soil to cover the two trays)



2 TRAYS
(about 50 cm x 30 cm in size)

CRESS SEEDS



2 BRICKS
OF THE SAME SIZE

1 Activity 1: Learn about the composition and formation of soil

indoor

This activity should take **25 minutes**.

1. Cut the avocado lengthwise into two parts. Explain to the pupils that the avocado represents the Earth. The big seed in the centre of the avocado stands for the Earth's hard core, and the flesh represents the Earth's mantle. The avocado's thin peel represents the Earth's crust, which is what we stand on. The crust is about 35 kilometres thick. Much – but not all – of this thin surface is covered with soil. This soil layer might be only a few centimetres thick in some areas but may be several metres thick in other areas.
2. Tell the pupils that you will now explain what soil is made of and how it is formed.
3. Draw the outline of a bucket on the board (see Figure 3.3). Ask the pupils to copy your drawing into their excercise books.

4. Bring out the glass or bucket (hereafter called the real container) you brought in, as well as the stones, water and organic materials.
5. Then, start to fill in the bucket by drawing the components of the soil on it. While doing so, do the same with the real container.
6. First draw the proportion of inorganic material – almost half (45 percent) of the soil. Explain that inorganic material is the non-living component of the soil, such as sand, clay and silt.
7. Fill in half the real container with small stones.
8. Then draw waves on Figure 3.3; these represent water, filling about one-quarter (25 percent) of the bucket.
9. Fill one-quarter of the real container with water.
10. Draw small circles on Figure 3.3 to represent air, filling another one-quarter (25 percent) of the bucket.
11. Blow some air into the real container.
12. Finally, draw leaves, sticks and earthworms on Figure 3.3 to represent organic matter (5 percent of the bucket). Explain that organic matter is the term used to refer to dead things in various stages of decomposition, such as wood, leaves, twigs, roots and other dead plant parts, as well as dead animals.
13. Fill one-quarter of the real container with the organic matter you brought in.
14. Now the drawn bucket and the real container are full. They show that soil consists of four main components – inorganic material, water, air (not visible in the real bucket) and organic matter.
15. **Explain:**
    - Nearly half the soil mass is **inorganic material**.
    - About one-quarter of the soil is **air**, which occupies spaces called pores in the inorganic material.
    - **Water** seeps into the soil through pores and channels. The soil will contain more water after rain and less in a long dry period.
    - **Organic matter** comprises only a small part of the soil. This is mostly in the humus, which is the dark material that forms on top of the soil as plant and animal matter decays.

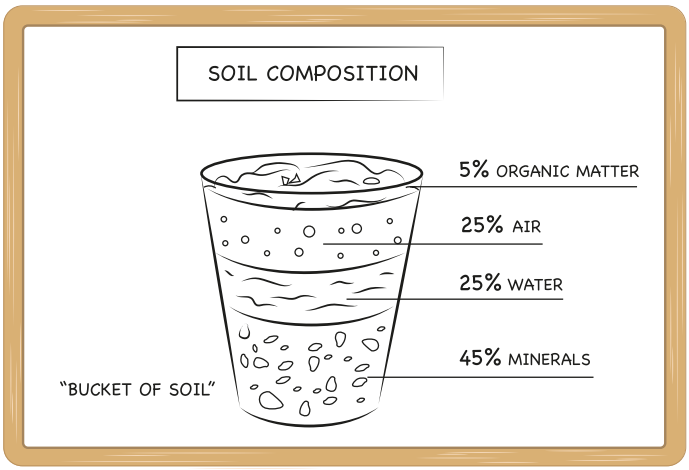


Figure 3.3. The components of soil

16. Ask the pupils to check that their drawings are complete. Tell them that the layers in the bucket are not the same as the soil horizons – they only show the proportions of inorganic material, air, water and organic matter in soils, not how these are distributed.
17. Now take the container, mix up the components inside and explain to the pupils that now you have created real soil!
18. Tell the pupils that soil formation is a complex process, and it takes a lot of time. Write "Soil formation" on the board and explain that soil formation involves:
    - the breakdown of the bedrock layer (the layer of solid rock that is under the soil); and
    - the decomposition of wood, leaves, twigs and other organic material (dead plants and animals, as well as waste products) on the surface.
19. Draw the picture shown in Figure 3.4 on the board and ask the pupils to copy it into their exercise books.

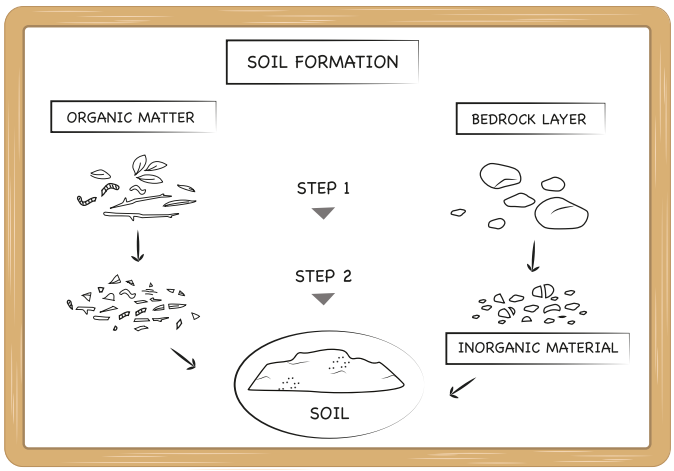


Figure 3.4. Soil formation

20. **Explain:** Tell the pupils that some soils are less than 100 years old and others are millions of years old. Soil are ecosystems – they differ, depending on many factors.
21. Write on the board six things that affect the type of soil that forms in an area (write only the text in bold) and read the explanations that follow:
    - **Type of parent material.** Frost, wind, snow and sunshine affect the bedrock, helping break it down into smaller pieces that form the inorganic material – clay, sand and silt.
    - **Plants, animals and microorganisms.** After the bedrock is broken into smaller pieces, plants, animals and microorganisms break it down further.
    - **Climate.** High temperatures, humidity and precipitation accelerate the process of breaking down the bedrock.
    - **The features of the land.** Flatter areas are usually stickier and more fertile than the slopes.
    - **Time.** Soil formation is a very slow process.
    - **Humans.** Human activities, such as the construction of human infrastructure, deforestation and agriculture can affect soils.
22. Ask the pupils to copy these six factors (only the text in bold) into their exercise books.

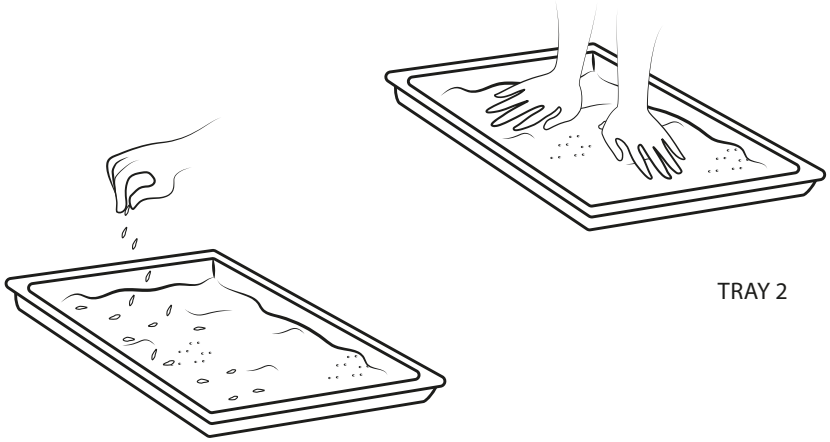
2 Activity 2: Sow ground cover

outdoor

This activity should take **15 minutes**.

Note: If it is not possible for the pupils to do this activity, the teacher should prepare the two test trays.

1. Organize the class into two equal-sized groups.
2. One group will pour soil from the bucket into one of the trays ("tray 1") and spread it evenly. Then, they will sow cress seeds evenly over the soil and water it lightly.
3. The other group will pour soil from the bucket onto the other tray ("tray 2") and press it down firmly.
4. After four or five days, the cress in tray 1 should have grown to about 2 cm high.

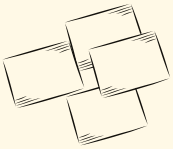


LESSON 10

How do forests and soil interact?

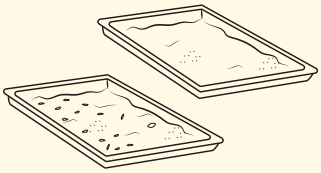
10

Required materials

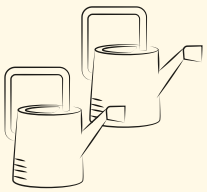


4 MANILA CARDS

ADHESIVE TAPE



TRAYS PREPARED
in Lesson 9, Activity 2



2 WATERING CANS
with the same quantity of water

Preparation for the lesson

Draw the nutrient cycle shown in Figure 3.5 on the board, but do not add the words in the four boxes yet. Write each of the four steps in the nutrient cycle – "Dead plants and animals", "Soil organisms", "Organic material" and "Plants" – on a separate piece of paper (e.g. manila cards). You will stick these onto the board with adhesive tape in Activity 1.

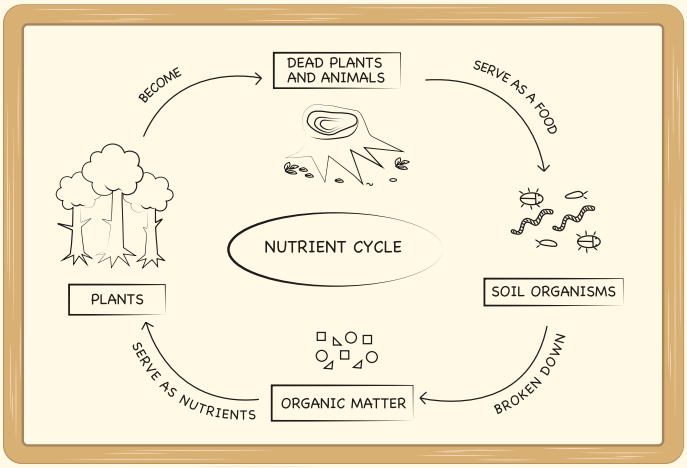


Figure 3.5. The nutrient cycle

1 Activity 1: Learn the nutrient cycle

indoor

This activity should take **20 minutes**.

1. Remind the pupils of the exercise that involved drawing (in a "bucket") the four components of soil.
2. Ask them whether they remember what those components are and invite a few pupils to share their answers.
3. Reiterate to the class that the four components of soil are:
   - inorganic material (rocks, stones, sand, silt and clay);
   - air (in pores);
   - water; and
   - organic matter (animals, plants and microorganisms).
4. **Explain:** Soil organisms play an important role in soil fertility – the more fertile the soil, the better plants grow. Soil organisms are the Earth's recycling system, which is known as the "nutrient cycle".
5. Ask the pupils to look at the picture of the nutrient cycle you have drawn on the board. Show them the four cards with the four parts of the nutrient cycle written on them. Ask the pupils where you should put each card. Stick them in the right position on your drawing, using adhesive tape.
6. Now, **explain** the nutrient cycle to the pupils, as follows:
   - **Dead plants and animals** – when plants (or parts of plants, such as leaves) and animals die, they decompose on the ground, forming organic matter. Often, animals will eat the dead (and living) plant and animal parts and distribute them in the form of waste.
   - **Soil organisms** – microorganisms digest the dead plants and animals and break them down into nutrients.
   - **Nutrients** – these dissolve in water, which carries them to the roots of living plants.
   - **Plants** – plants absorb the nutrients and use them to grow. When those plants die, they return to the soil, where they decompose, and the cycle continues.
7. Conclude by saying, "In nature, there is no waste."
8. Ask the pupils to copy the drawing of the nutrient cycle into their exercise books.

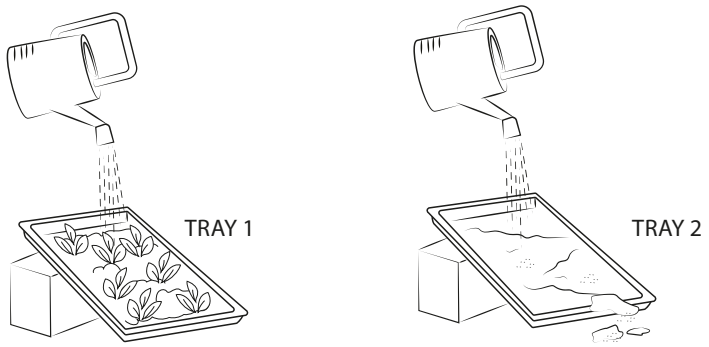
2 Activity 2: Observe and discuss the contributions of forests to soil health

outdoor

This activity should take **15 minutes**.

1. Take the pupils outside.
2. Organize the class into two equal-sized groups. Assign tray 1 to one group and tray 2 to the other.
3. Ask one pupil from each group to place the group's tray on the ground, with a brick under one end to form a slope. Important: the slope should not be so steep that the soil slides down the tray.

4. When both trays are in position, side by side, ask one pupil from each group to sprinkle water onto the group's tray. Tell the members of each group to observe the colour of the water that flows out at the bottom of the tray. The water-pourers should start slowly and then increase the rate at which the water pours onto the tray. At its fastest rate, the amount of water falling onto the soil will simulate rain in a thunderstorm.



Note:
Tray 1 stands for an area of soil covered with trees and plants. The cress represents the trees and plants (vegetation).
Tray 2 stands for an area of soil without vegetation.

5. On tray 1, which is covered with cress, very little soil will leak from the tray during moderate "rain", and a relatively small amount will leak out in the "thunderstorm".
6. The water flowing out of tray 2 (with no cress growing) will be much dirtier. This is because there is no cress to hold the soil together, resulting in more soil being lost.
7. Ask the pupils what they observed.
8. After two or three pupils have answered, **explain:**
   - What you just observed is called soil erosion. This is the loss of soil from an area due to water flow or strong wind. Soil erosion happens everywhere, especially in regions with high rainfall. But we don't want it to happen too quickly because, when it does, we lose valuable soil, reducing our capacity to grow crops, forests and grasslands.
   - Erosion removes the fertile layers of soils and washes them into rivers and the sea.
   - Land that suffers from severe erosion becomes degraded, meaning it is less able to grow crops, forests and grasslands.
   - Soil erosion is most extreme when the land has few plants growing on it.
   - This is because plant roots and other organic matter hold the soil together. When land is covered with healthy forest:
     - The roots of trees and shrubs help hold the soil together.
     - Trees reduce the force of the wind and shield the soil from the impacts of raindrops, which also helps minimize soil erosion.
9. Ask the pupils to copy the following sentence into their exercise books:

   Roots give plants a firm footing in the soil and also help hold the soil together. This helps keep lands fertile and capable of growing crops, forests and grasslands.

3 Activity 3: Reflect on the value of soil

indoor

This activity should take **5 minutes**.

1. Write the text in item 4 below on the board, one point at a time. Leave the underlined words blank.
2. As you write, ask the pupils to copy the sentences into their exercise books.
3. Invite the pupils to propose the missing words and then, on the board, write the correct ones in the blank spaces.
4. Continue until you have completed all the points.
   - Soil is valuable because it:
   - » is essential for growing **food**;
   - » is home to many **animals and plants**;
   - » filters **water**;
   - » provides the nutrients that plants need to **grow**;
   - » anchors the **roots** of trees and other plants; and
   - » stores large amounts of **water**.

   - Forests are important for soil because they:
   - » hold **soil in place** with their roots;
   - » maintain water and **nutrient** cycling;
   - » provide material to **create new soils** through the decomposition of leaves and dead tree parts;
   - » increase the soil's capacity to store **water**; and
   - » minimize soil **erosion** by intercepting raindrops and reducing wind speed.
5. Ask the pupils to add the missing words to the sentences they have written in their exercise books.

Notes

[1] **FAO**. 2017. Cherishing the ground we walk on. In: *Food and Agriculture Organization of the United Nations*. Cited 22 December 2022. www.fao.org/fao-stories/article/en/c/1069275/?utm_source=twitter&utm_medium=social+media&utm_campaign=faoknowledge

[2] **Intergovernmental Technical Panel on Soils**. 2020. *Towards a definition of soil health*. FAO. www.fao.org/3/cb1110en/cb1110en.pdf

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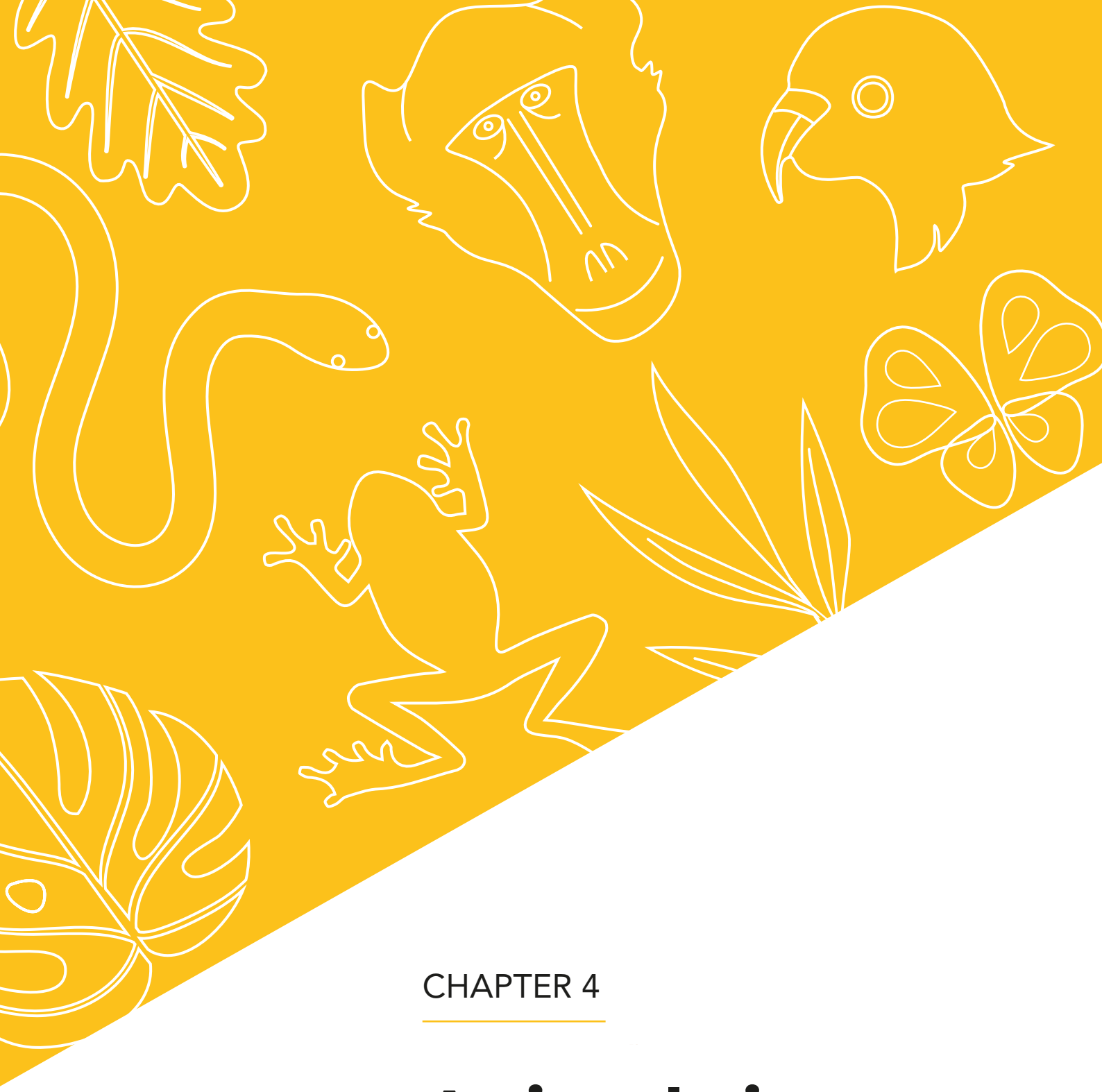

CHAPTER 4

Animals in the forest

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Overview

In this chapter, the pupils will learn about some of the most common forest animals in the United Republic of Tanzania and their habitats, characteristics and classification. This will be done through class discussions, a mime game, and a review of what the pupils have learned through an interactive activity in the classroom.

Objectives

By the end of the chapter, the pupils will be able to:

- identify various animals commonly found in Tanzanian forests;
- describe the characteristics and habitats of typical forest animals in the United Republic of Tanzania; and
- understand the differences between vertebrate and invertebrate animals.

Background information

What animals are found in the forest?

Forests are home to many species of animals, which play important roles in maintaining forest ecosystems. For example, mammals and birds help disperse the seeds of trees and other plants, and insects help pollinate flowers (see Chapter 6).

Animals are either vertebrates or invertebrates. Vertebrates have a vertebral column ("backbone" or "spine") and invertebrates do not.

Invertebrates found in forests include insects such as butterflies, annelids such as earthworms, arachnids such as spiders, and gastropods such as snails. More than 90 percent of all animals are invertebrates.

The five main groups of vertebrates are fish, amphibians, reptiles, birds and mammals.

- **Fish** are the world's oldest vertebrates. They breathe through gills and have no lungs (the exception being lungfish). Fish lay eggs and live only in water. They are cold-blooded, which means that their body temperature varies depending on the temperature of the surrounding environment.
- **Amphibians** are also cold-blooded. Most have moist, smooth skin and hatch from eggs in water. When young, amphibians live only in water and breathe through gills. As they become adults, however, they develop lungs to enable them to breathe air, and they can then live both in the water and on land. The term "amphibian" comes from the Ancient Greek term amphibios, which means "having a double life".
- **Reptiles**, like fish and amphibians, are cold-blooded, and they have dry, scaly skin. Most reptiles hatch from eggs, but a few species give birth to live young. All reptiles have lungs.
- **Birds** are warm-blooded; this means that their body temperature remains constant and does not change with the temperature of the environment. Birds have feathers instead of hair or fur. They also have wings, hard beaks, and claws at the ends of their toes. Most birds can fly (exceptions include ostriches and penguins). Young birds hatch from eggs and, in contrast to mammals, are not suckled by their mothers.
- **Mammals**, like birds, are warm-blooded and have a constant body temperature. Most mammals have hair or fur on their skin and give birth to live young (rather than eggs). Newborn mammals are suckled with milk from their mothers' mammary glands, from which the term "mammals" is derived.

What animals inhabit the forests of the United Republic of Tanzania?

The forests of the United Republic of Tanzania are home to thousands of invertebrate species and many vertebrate species.

Some of the **vertebrates** found in Tanzanian forests are:

- fish: emperor, goatfish, grouper, parrotfish, rabbitfish, surgeonfish, sweetlips and tilapia (e.g. Nile tilapia);
- amphibians: frogs (e.g. the Mount Meru stream frog), toads and caecilians (snake-like amphibians);
- reptiles: chameleons (e.g. the Usambara three-horned chameleon), crocodiles, lizards, snakes, tortoises and turtles;
- birds: African jacana, African openbill, ashy starling, black crake, grey-breasted spurfowl, hamerkop, lovebird, ostrich, owls, pin-tailed whydah, tinkerbird, eagles (e.g. the crowned hawk-eagle) and vultures; and
- mammals: antelopes, bats (e.g. the Pemba flying fox), gazelles, hare, monkeys, rabbit, shrew, elephant, cheetah, lion, giraffe, leopard, rhino and zebra.

FISH

Picture 4.1. Nile tilapia

AMPHIBIANS

Picture 4.2. Green frog

REPTILES

Picture 4.3. Chameleon

BIRDS

Picture 4.4. Eagle

MAMMALS

Picture 4.5. Monkey

Invertebrates found in Tanzanian forests include:

- insects – beetles, butterflies (e.g. giant swallowtail), termites and bees;
- arachnids – spiders (e.g. black widow), scorpions, mites and ticks;
- annelids – earthworms (e.g. common earthworm), leeches and lugworms; and
- gastropods – snails (e.g. garden snail), slugs, limpets and sea hares.

INSECTS

Picture 4.6. Butterfly

ARACHNIDIS

Picture 4.7. Banded-legged golden orb web spider

ANNELIDS

Picture 4.8. Earthworm

GASTROPODS

Picture 4.9. Snail

Which habitat for which species?

The world's forests are incredibly diverse: they host 80 percent of amphibian species, 75 percent of bird species and 68 percent of mammal species.[1] Each species has its own habitat (habitats are environments suited to the survival of particular species, where they can find food, shelter and protection from predators). Forests contain many habitats. For example, some animals live on or in the ground, some inhabit treetops, some live near water and some live in water. For example:

- Chameleons live in rainforests but also occur in savannahs, grasslands and semi-arid areas. Chameleons eat insects such as locusts, flies and crickets, using their long sticky tongues to strike and capture prey.
- Some monkeys live in trees, and some live on the ground and climb trees for food and to escape predators. Monkeys eat plants and small animals – a typical diet might include nuts, fruit, seeds, flowers, birds' eggs, lizards, insects and spiders.
- Pemba flying foxes live in large forest trees and also mangroves.
- Many birds live in the forests, grasslands and vichaka shrublands of the United Republic of Tanzania. Eagles, for example, nest mainly on the rocky tops of hills and mountains and in tall trees in forests. They feed on fish, snakes, lizards and smaller birds.
- Frogs live in moist environments in forests, savannahs and grasslands. Some species shelter in trees and leaf litter, and others live in ponds and other wetlands. Small frogs eat insects such as flies and mosquitoes. Larger frogs may eat grasshoppers, worms, small snakes, mice, baby terrapin and other (smaller) frogs.
- Tilapia are fish that inhabit shallow streams, ponds, rivers and lakes. Less commonly they are also found in brackish water. Tilapia eat a wide range of food, including green leaves, plankton and insect larvae.
- Butterflies feed on nectar from flowers. They occur in many types of environments worldwide.

LESSON 11

Focus on forest animals

11

Required materials

ADHESIVE TAPE

1 LARGE SHEET OF PAPER
(poster size)

1 Activity 1: Brainstorm on forest animals

indoor

This activity should take **5 minutes**.

1. Ask the pupils if they can name some animal species found in Tanzanian forests.
2. Write their responses on the left-hand side of the board. As you write the names, ask the pupils to copy them into their exercise books.

Tip: Make sure there is at least one species from each main group of animal in the list (the main groups are amphibian, bird, fish, mammal and reptile for vertebrates; and insect, annelid, arachnid and gastropod for invertebrates).

2 Activity 2: Classify forest animals

indoor

This activity should take **20 minutes**.

1. Draw the images in Figure 4.1 on the right-hand side of the board. If there is insufficient room, draw the picture on a large (poster-sized) sheet of paper. If you prefer not to draw, simply write the names of the animals. As you draw or write, ask the pupils to copy the drawings or the names of the animals into their exercise books.

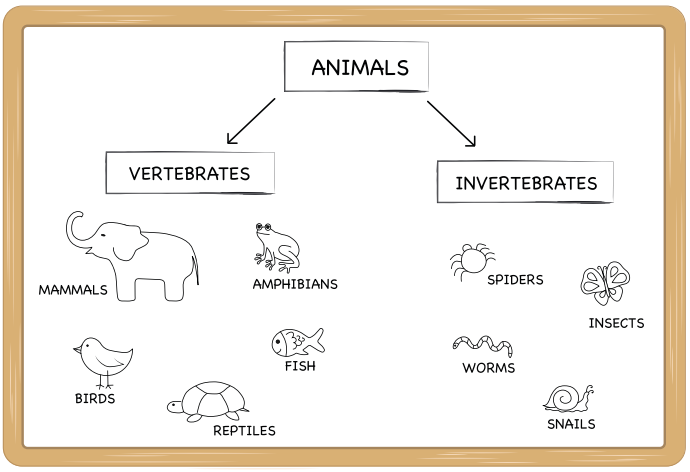


Figure 4.1. Vertebrate and invertebrate animals

2. **Explain:**
   - » Animals are either vertebrates or invertebrates.
   - » Vertebrates are animals with a vertebral column (backbone or spine), while invertebrates have no vertebral column.

Tip: Tell the pupils to feel their own spines at the base of their necks. People are vertebrates.

   - » There are five main groups of vertebrates: amphibians, birds, fish, mammals and reptiles.
   - » Examples of invertebrates are insects such as butterflies, annelids such as earthworms, arachnids such as spiders, and gastropods such as snails.

3. Ask the pupils to classify the animals written on the left side of the blackboard. Ask the following questions to encourage discussion:

- Which of these animals in Tanzanian forests have spines (are vertebrates), and which do not (are invertebrates)?
- Can you identify all the mammals written on the board?
- How many kinds of birds are written on the board?
- Can you see any insects written on the board?
- Are there any amphibians or fish written on the board?

3 Activity 3: Discuss characteristics and habitats

indoor

This activity should take **15 minutes**.

1. Underline, or add and underline if not already on the board, the following six animals: chameleon, monkey, eagle, frog, tilapia and butterfly.
2. Ask the following questions to start the discussion and ask one pupil at a time to answer. If some answers are incorrect or missing, provide the correct answer.

- What do these animals look like? Who can describe them?

Answers

- Chameleons look like lizards, and they range in length from 1.5 cm (centimetres) to 70 cm. Although they are typically a similar colour to the environment where they live (e.g. chameleons that live on trees are green), they are also well known for their ability to change their skin colour to be "invisible" to predators. Chameleons have protuberant round eyes that offer 180° vision – and the two eyes can move in different directions to each other.
- Some monkeys are as small as 12 cm and weigh less than an apple. Others are as tall as 1 m (metre) and weigh up to 36 kilograms. Most monkeys have long tails and forward-facing eyes.
- Eagles have powerful hooked beaks for tearing flesh from their prey. They also have strong legs, powerful talons (claws) and keen eyesight.
- Frogs come in many colours and sizes. The back feet of aquatic frogs are webbed to help them swim and leap.
- Tilapia are scaly fish with a large continuous dorsal (upper) fin, a long snout and big lips.
- Butterflies come in many colours and sizes, have scaly wings, six legs and a pair of antennae.

- What do these animals eat and where can we find them?

Answers

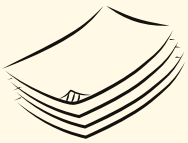
- Most chameleons eat insects such as locusts, flies and crickets using their long sticky tongues to strike and capture prey. Chameleons live in rainforests, savannahs, grasslands and drylands.
- Monkeys eat plants and small animals. For example, a monkey's diet might include nuts, fruit, seeds, flowers, birds' eggs, lizards, insects and spiders. Some monkeys live in trees, and some live on the ground and only climb trees for food or to escape predators.
- Eagles feed on fish, snakes, lizards, small birds and small mammals such as mice. They nest mainly on the rocky tops of hills and mountains and in tall trees in forests.
- Small frogs eat insects such as flies and mosquitoes. Larger frogs might eat grasshoppers, worms, small snakes, mice, baby terrapin and other (smaller) frogs. They live in humus and other moist areas in forests and savannahs, as well as in ponds. Tree frogs live mainly in trees in warmer climates.
- Tilapia eat a wide range of food, including green leaves, plankton and the larvae of insects such as mosquitoes and water beetles.
- Most butterflies feed on nectar from flowers. Butterflies occur in many environments worldwide.

LESSON 12

How many forest animals can you name?

12

Required materials



SHEETS OF PAPER
1 for each group of 8–10 pupils

TIMER/STOPWATCH

1 Activity 1: Making a list of forest animals

indoor

This activity should take **25 minutes**.

1. Organize the class into groups of eight to ten pupils. Give each group a sheet of paper.

> **Note:** The pupils will learn more effectively in smaller groups. To be able to discuss the results of this activity adequately, however, each group should have no fewer than eight pupils.

2. Tell the groups to think of as many names as possible of forest animals in the United Republic of Tanzania and to write these on their sheets of paper. The groups should work quietly to avoid disturbing the other groups. Tell them they have ten minutes and start the timer.
3. When the timer buzzes, tell the groups to stop working.
4. Ask the groups to read out their lists, one after the other. The groups will receive one point for each correct answer.
5. At the end of the activity, ask each group to tally the number of correct answers. The group with the most points wins.

2 Activity 2: Classify the animals

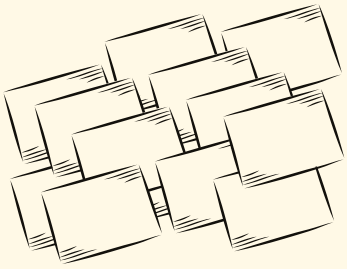
Optional (if there is enough time): Classify the animal species presented in the Activity 1 in a short discussion. Possible questions include the following:

- Is it a vertebrate or an invertebrate?
- What kind of vertebrate is it (i.e. mammal, bird, reptile, amphibian or fish)?
- What kind of invertebrate is it (i.e. insect, annelid arachnid or gastropod)?

LESSON 13

Play a forest animal miming game 13

Required materials



12 MANILA CARDS

Preparation for the lesson

On 12 manila cards, write the names of animal species typically found in Tanzanian forests (a different animal on each card), which pupils will mime or mimic. You may use the examples from the brainstorming lesson. Ensure that you select one example from each of the main animal groups – amphibians, birds, mammals, fish, reptiles and insects. Fold each manila card in half so the writing cannot be seen. You will give one card to each group for the mime game.

Note: Each group in the mime game should have about eight to ten pupils. For larger classes, you can write additional examples of animals (one animal per card) to ensure that each group mimes a different animal species. See the background information of this chapter for more examples of animal species.

1 Activity 1: Guess the mimed animal

indoor

This activity should take **40 minutes**.

1. Organize the class into groups of eight to ten pupils. Give each group one of the manila cards you previously prepared with the name of an animal written on it. Tell the pupils that each group should keep their animal secret and not tell the other groups.

2. Explain the task to the pupils, as follows:
   - You are going to present your animal to the other pupils through mime. This means that you have to show the main characteristics of your species through movement, gestures and facial expressions. You are not allowed to talk, make noises or write anything down.
   - The other groups will try to guess the animal you are representing.
   - The groups will have 5 minutes to discuss how to present their animals to the class.
3. Remind the pupils to discuss quietly so that they can keep their animal secret until they present it in the game.
4. After 5 minutes, ask each group, one by one, to present its animal through mime. Ask the other groups to guess which animal is being mimed. If the animal is guessed correctly, the next group will present its animal. If the answer is wrong, the group will continue to mime until the correct answer is given or you provide it. Invite pupils who guessed correctly to explain which characteristics helped them recognize the animal being mimed.

> **Note:** Calculate how much time to allocate to each group to ensure that all groups can perform their mimes within the time allotted for this activity.

LESSON 14

Become a forest animal expert

14

Required materials

1 SMALL, LIGHTWEIGHT BALL THAT CAN EASILY BE THROWN AND CAUGHT IN CLASS
(or a piece of paper scrunched into a ball)

Preparation for the lesson

Before the class, create a large picture of the classification of animal species by copying Figure 4.2 onto the board.

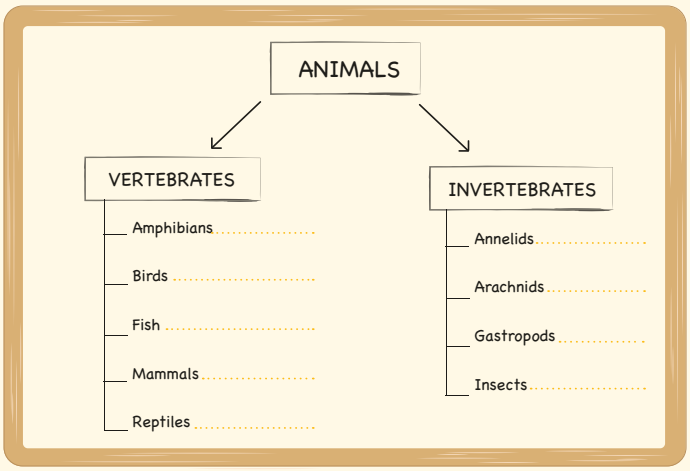


Figure 4.2. Classifying animals

1 Activity 1: Repeat the classification of forest animals

indoor

This activity should take **10 minutes**.

1. Show Figure 4.2 to the class.
2. **Explain:**
   - Animals are either vertebrates or invertebrates. Vertebrates have a vertebral column (backbone or spine), and invertebrates do not.

- Vertebrates are further divided into the following groups: mammals, birds, fish, reptiles and amphibians.
- Invertebrates include insects such as butterflies, annelids such as earthworms, arachnids such as spiders, and gastropods such as snails.

3. Ask the pupils to copy the Figure into their exercise books.
4. Ask the pupils to recall the animals they mimed in the previous lesson. Ask some pupils to classify them, and add the answers to the Figure on the board (Figure 4.3).
5. Ask the pupils to put these into the Figures they drew in their exercise books.

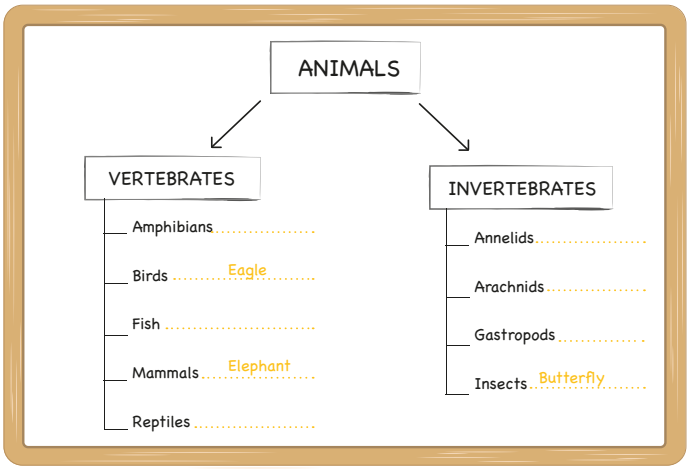


Figure 4.3. Classifying animals

2 Activity 2: Become animal experts

indoor

This activity should take **30 minutes**.

1. Name one of the animal species on the blackboard.
2. Throw the ball to a pupil and ask, "What does this animal look like?"
3. Allow the pupil to describe the animal. Other pupils may help.
4. When the question has been answered correctly, ask the pupil to throw the ball to another pupil. Ask the next question to the pupil now holding the ball (see the list below).
5. The game continues until all the questions below have been answered for the first animal. Then, name another animal on the blackboard and go through the same set of questions as the ball moves around the class. Continue the exercise for the other animals.
6. Ensure that as many pupils as possible get the chance to catch the ball and answer a question.

Questions:

- What does the animal look like?
- Where does the animal live?
- How does the animal behave and what does it eat?
- Do humans use the animal? For what?

Preparation for the next lesson

Ask the pupils to bring in any dead bees they manage to collect in a container, but warn them that dead bees can still sting and they should try not touch them with their bare hands. As another option, bring these items in yourself.

Notes

[1] **FAO & UNEP.** 2020. *The State of the World's Forests 2020: Forests, biodiversity and people*. Rome, FAO and United Nations Environment Programme (UNEP). 214 p. https://doi.org/10.4060/ca8642en

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CHAPTER 5

The life of bees in a colony

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Overview

In this chapter, the pupils will learn through exploration and discussion about different species of bees and the behaviour and social life of a colony of honeybees. The pupils will perform a play about the roles of honeybees in a colony and in ecosystems. To prepare for the play, the pupils will make hats to signify the type of honeybee they will be playing. Finally, the pupils will discuss and exchange ideas to develop a firm understanding of life in a colony of honeybees.

Objectives

By the end of the chapter, the pupils will be able to:

- describe the main parts of a bee;
- identify the various roles that honeybees play in a colony and how a colony works;
- understand how honeybees have evolved alongside flowering plants; and
- gain an awareness of the importance of bees in ecosystems.

Background information

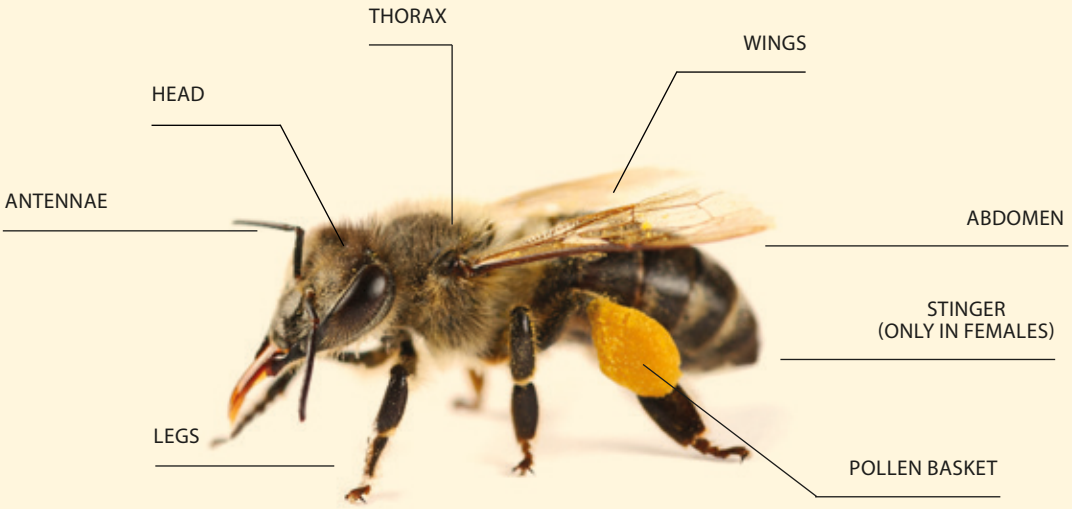
What are the parts of a bee's body?

There are more than 20 000 species of bees in the world,[1] and they are found on every continent except Antarctica. Bees occur in a range of colours. Many species have black and yellow stripes, but there are also black, green, red and blue bees. Bees range in size, too, from a few millimetres in length to more than 2 cm (centimetres).

Like all insects, bees' bodies have three main parts – head, thorax and abdomen.

- **Head.** The heads of bees feature five eyes (three small simple eyes and two large compound eyes), two antennae, and a mouth with a proboscis. The proboscis is like a human tongue; it helps bees reach the centres of flowers to collect nectar.
- **Thorax.** The thorax holds six legs and two pairs of wings. Honeybees can fly at speeds as high as 32 kilometres per hour,[2] which is almost as fast as the fastest human can run. In some bees, including honeybees, the rear legs have structures called "pollen baskets", which the bee uses to carry the pollen it collects from flowers.
- **Abdomen.** The abdomen houses the reproductive organs. In worker honeybees, it also features the wax glands the bee uses to produce wax for building nests. In female bees, the abdomen has a stinger (males lack this). Honeybees only use their stingers when in extreme danger because they typically die after releasing their stings.

The bodies of bees are mostly covered by hair, which helps in gathering pollen and transporting it from flower to flower (Picture 5.1).



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Picture 5.1. A honeybee's body parts

How does a honeybee colony work?

Some bee species live on their own and dig nests in the ground (solitary bees). Others – such as bumble bees and honeybees – live in groups called colonies.[3] Forests are natural habitats for bees, providing places where bees can build their nests, and plants where they can collect pollen and nectar.

Honeybees originated more than 80 million years ago from a species of solitary wasp. Today, honeybees form colonies containing many individual bees. Honeybee colonies live in wild nests (Picture 5.2) or in man-made hives (Picture 5.3). The nest of a colony of honeybees consists of structures made of wax called combs. Combs have two main purposes – to store honey (called honeycombs) and to raise bee eggs, larvae and pupae (called brood cells). Honeybees typically build their nests in rock crevices and hollow trees, and on tree branches.

Picture 5.2. Honeybees in wild nest

Picture 5.3. Honeybees in man-made hives

In any colony, there are three main castes of bees, each with different roles: the queen, drones and workers.

Queen. There is only one queen in a colony, and her role is to lay eggs. She is the mother of all male and female bees in a colony, and she spends her life producing eggs and eating, fed by worker bees. When a new queen bee is born, the new queen leaves the nest to mate in the air with drones from other colonies. After mating, she returns to her original colony and replaces the old queen, who swarms with a large part of the colony to establish a new colony elsewhere.

Drones. All drone bees are male. For most of their lives, drones rest, eat and grow strong. Their primary role is to fly off and mate with new queens hatched in other colonies. Drone bees die after mating. Of the three castes of bees in a honeybee colony, only drones lack stingers.

Worker. All worker bees are female. Their job is to clean the nest, collect pollen and nectar from plants to feed the colony, make wax and honey, and take care of the larvae that develop from eggs laid by the queen bee. Worker bees cannot reproduce. Several castes of worker bee can be distinguished:

- *Foragers* are in charge of collecting nectar and pollen. They leave the nest and may fly up to several kilometres to find flowers and collect nectar and pollen. A forager bee returns to the nest when her "honey stomach", called a crop, is full of nectar or her pollen baskets are full of pollen. When back in the nest, a forager bee will deposit her pollen in an empty cell and pass the nectar by mouth to house bees. The pollen will turn into bee bread, which is the main source of protein for feeding the colony.
- *House bees* store nectar in the honeycombs and fan it with their wings. This reduces the water content of the nectar and makes it thicken into honey. The cells where the honey has been stored are sealed with wax. The bees use the honey as a source of sugar to feed the colony.

- *Caretakers* tend the bee eggs, pupae and larvae in brood cells. The eggs turn into larvae, then pupae, then worker (female) and drone (male) bees. Female eggs develop into worker bees in 19–20 days. Male eggs develop into drone bees in 24 days. New queens develop in 14 days.
- *Housekeepers* clean the brood and honeycomb cells, remove dead bees from the nest, and seal cells with wax to enable the larvae to grow and develop into young bees.
- *Guardians* guard the colony against predators such as insects, spiders, amphibians, birds, reptiles and mammals.

A colony of these honeybees usually hosts between 20 000 and 80 000 bees, depending on the time of year. It includes one queen, hundreds of drones and thousands of workers. The East African lowland honeybee is native to the United Republic of Tanzania.

How are bees and flowers mutually dependent?

Flowers and bees have evolved together over millions of years, with flowers becoming more attractive to bees and bees becoming more effective pollinators (see Chapter 6). Bees pollinate flowering plants as they fly from flower to flower to collect nectar and pollen. In turn, flowers provide bees with nectar and pollen to feed their colonies.

Bee numbers have been dropping in recent years due to the destruction of their habitat (e.g. forests), the use of pesticides in agriculture and climate change, which is increasing temperatures and causing changes in flowering times. The aim of World Bee Day, which is celebrated every year on 20 May, is to raise awareness of the important roles of bees and the need to protect them.

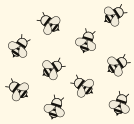
Picture 5.4. A honeybee visiting a flower

LESSON 15

Prepare for a bee colony role play

15

Required materials



COLLECTED DEAD BEES
(if any)

A4 SHEETS OF PAPER

1 Activity 1: Explore and discuss bees

indoor

This activity should take **15 minutes**.

1. Ask the pupils to show any dead bees they managed to collect.
2. Draw Figure 5.1 on the board. Pupils will find the same drawing in their pupils' books. Ask the pupils to copy the body parts into their exercise books.

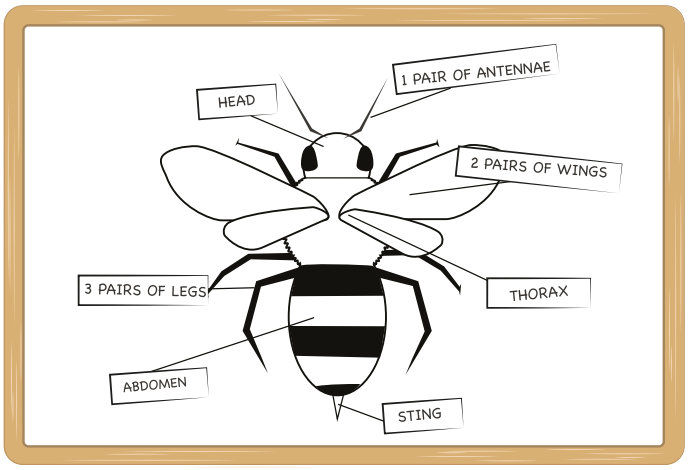


Figure 5.1. The main parts of a honeybee

3. Tell the pupils to examine and describe the physical features of a bee, such as the number of legs, the hairy body and wings. Use the following questions to stimulate discussion:

- ► What castes of honeybees are found in a bee colony?
- » **Answer:** A queen, drones and workers.
- ► How many wings do bees have?
- » **Answer:** Four wings.
- ► Can you describe a bee's body?
- » **Answer:** It has three main parts – head, thorax and abdomen. Attached to the head is a pair of antennae. Attached to the thorax are three pairs of legs and four wings.
- ► Where do honeybees live?
- » **Answer:** In colonies in wild nests and in human-made hives.
- ► How many species of bee are there?
- » **Answer:** Over 20 000 species.
- ► Do all bee species live in colonies?
- » **Answer:** No, some bees, known as solitary bees, live on their own and dig nests in the ground.
- ► Why are bees important for humans?
- » **Answer:** Bees pollinate flowers. Many of the crops that people eat depend on pollinators to grow. (Tell the pupils they will learn more about pollination in the next chapter.) Bees also produce honey, which people like to eat.
- ► How do honeybees make honey?
- » **Answer:** Honeybees have a special "honey stomach" called a crop, where they collect the nectar they extract from flowers. The bees in charge of collecting nectar and pollen are called foragers. When they return to the nest, the forager bees pass the nectar by mouth to house bees, which store it in honeycombs and fan it with their wings to thicken it into honey.

4. Conclude by reading the correct answers above.

2 Activity 2: Prepare for role-play

indoor

This activity should take **25 minutes**.

Important: This activity is only to prepare for the play. The pupils will perform the play in a later lesson.

1. Explain to the pupils that, in a later lesson, they will perform a play to learn more about life in a honeybee colony.
2. Organize the class into two groups – performers and observers. You will need 48 pupils for the performer group, who will all wear coloured hats (Table 1 lists the number of hats needed for the various roles). The rest of the pupils will be in the observer group, and they will wear hats labelled with the letter "O".

Note: If the class is small, you may reduce the number of observers and worker bees (see Table 5.1).

3. Explain the role of each group – observers and performers – to the pupils.
4. Explain to the observers that their task will be to watch the play and answer some questions.
5. Write the following questions on the board and ask the observers to copy them into their exercise books. The performers will also hear the questions.

   - When did honeybees first appear on the Earth?
   - What do honeybees eat?
   - Where do honeybees live?
   - What are the different roles played by honeybees in a colony?
   - What tasks do worker bees do?
   - How is wax produced?

6. Explain to the performers that they will each be allocated a role in the play. Inform the pupils that an empty cardboard box will be used to represent a nest.
7. Assign roles to all the performers. Table 5.1 specifies how many pupils should fill each role. Read each role aloud to the class. Describe the hat for each role, which the pupils will wear during the play. They will make these hats in the next lesson.

Role	Number of pupils and the hats they must wear	What the pupils will do
Fern and conifer	2x 2 pupils 2 green paper hats	You are plants. Stand still and move your arms a little like branches in the wind.
Flowering plants	6x 6 pupils 6 newspaper hats	You are flowers. Squat in the scene, then stand up and move your arms when the wind appears.
Wind	2x 2 pupils 2 hats with W for wind written on them	You are the wind. Blow like the wind with your hands around your mouth.
First bee	1x 1x 1 pupil 2 hats needed: first a yellow/black striped hat, later a brown/black striped hat	You are the first bee on the scene. Fly around and look for food (wearing the yellow/black striped hat). Later (changing to the brown/black striped hat), fly around and look for delicious flowering plants with nectar.
Queen	1x 1 pupil 1 brown/black striped hat with a crown	Hello, queen bee. Stand near or in the box that symbolizes the nest that you live in. You will be laying eggs to keep the colony strong.

Drone	5x 5 pupils 5 brown/black striped hats with a male gender symbol	Lie near the nest. You are resting, eating and waiting for the moment to fly away and mate with a new queen from another nest.
Cleaner	2x 2 pupils 2 brown/black striped hats, holding 2 towels or small pieces of cloth	A nest must be tidy. As a cleaner, try to clean the nest with a towel or a piece of cloth.
Caretaker bee	4x 4 pupils 4 hats with red crosses	Stand near the nest and pretend to feed bee larvae inside the nest, as if they were babies.
Wax producer bees	2x 2 pupils 2 brown/black striped hats, holding 2 pieces of paper, ideally coloured yellow	You are the bees who produce the wax. Stand close to the nest and flap your arms like wings.
Guardian bee	2x 2 pupils 2 brown/black striped hats	Protect the nest! Stand in front of the box, guarding the nest against bee-eater attacks.
House bee	5x 5 pupils 5 brown/black striped hats and 5 straws made of reed, if available	Stand near the nest. Welcome the forager bees. With your straw (or using a finger), pretend to receive nectar from the forager bees and give it to another bee in the nest.
Forager bee	10x 10 pupils 10 brown/black striped hats and 10 straws made of reed, if available	Run with your straw (or use a finger) from flower to flower. Stay a while at each flower to collect all the nectar inside, sucking with your straw. After that run back to the nest and touch your straw to a house bee's straw. This symbolizes the transfer of nectar.
Bee-eating birds	3x 3 pupils 3 blue hats	Imagine you are a small bird. Run behind the forager bees trying to catch them. Who is faster?
Sign carrier	3x 3 pupils 3 hats with I for information written on them, carrying 3 big paper signs with numbers: 19 worker bee, 14 queen and 24 drone	Hold your sign up when you are told to do so during the play.
Observer	Hats with O for Observer written on them	Watch the play, review the questions in your notebooks and write down your answers during the play.

Table 5.1. Roles in the play about bees, and the hats for each role

LESSON 16

Make hats for a bee colony role play 16

Required materials

COLOURED CHALK, MARKERS OR ROLLS OF RIBBON
or pieces of cloth in different colours

A4 SHEETS OF PAPER
(approximately 2 per pupil)

5 ADDITIONAL A4 PAPER SHEETS
2 to be coloured yellow and 3 to be made into signs

2 NEWSPAPERS

GLUE OR PASTE

Option A: Use the colours, as described in the activity.

Option B: If coloured ribbons, cloth, chalk or marker pens are unavailable, write the name of the role on each hat.

1 Activity 1: Prepare your hat

indoor

This activity should take **40 minutes**.

1. Give each pupil (performers and observers) a sheet of A4 paper to make the hats that they will wear during the play.
2. Explain to the performers what each hat should look like, based on Table 5.1, which sets out the various types of hats, and how many of each (it also specifies sheets of paper coloured yellow, to represent wax). There will be a total of 49 hats for the 48 performers (the "first bee" has two hats).
3. Tell the observers that their hats will feature a large "O" (for observer) on the front.
4. Instruct the pupils to make their hats, as follows:
   - Take a piece of A4 paper (Figure 5.2, step a), curl it into a cone shape and glue or paste it to keep its shape (step b).
   - Then, colour the hats using coloured chalk or markers, or different-coloured ribbons or cloth (step c).

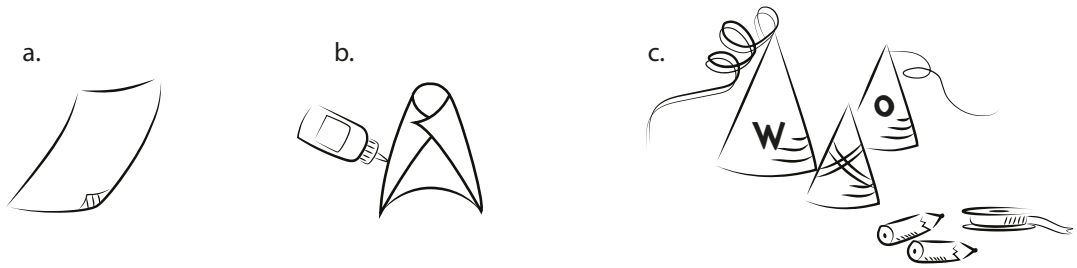


Figure 5.2. Three steps for making a cone hat

• **2 green hats** (fern and conifer)
• **6 hats** made of **newspapers** (flowering plants) » Students playing flowering plants should be given newspapers to make their hats.
• **2 hats with W** written on them (wind)
• **1 yellow/black striped hat** (first bee)
• **1 brown/black striped hat with crown** (queen)
• **5 brown/black striped hats** with **male gender symbol** (drones)
• **4 hats with red crosses** (caretaker bees)
• **22 brown/black striped hats** for the workers (first bee, cleaners, wax producers, guardians, house bees and forager bees) » The first bee will need to make two hats: one yellow/black striped hat and one brown/black striped hat. » The wax producers should also colour four A4 sheets of paper yellow (representing wax), if possible.
• **3 blue hats** (bee eating birds)
• **3 hats with I** (for information) written on them (sign carriers)
• **as many observer hats with a large O** written on them as there are students in the observer group

Table 5.2. Hats for the play

5. The three sign-holders should each prepare one sheet of A4 paper to show the class the number of days it takes each type of bee to grow from an egg to an adult bee (called the "incubation period"). The number of days should be written in large text on the sheets of paper, as follows:

   » Worker bee = 19–20 days
   » Queen bee = 14 days
   » Drone bee = 24 days

6. The pupils should then make their hats, signs and yellow sheets, and give them to you for safekeeping before the end of the school day.

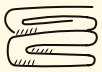
LESSON 17

Perform a bee colony role play

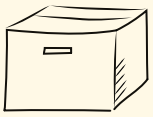
17

Required materials

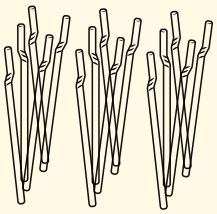
2 CUPS CONTAINING DRINKING WATER



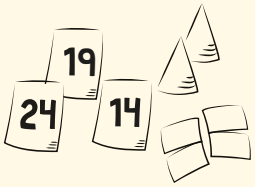
2 SMALL TOWELS or pieces of cloth



1 EMPTY CARDBOARD BOX to symbolize a bees' nest



15 REED DRINKING STRAWS (if unavailable, pupils can use their fingers)



HATS, SIGNS AND YELLOW PAPER SHEETS made in the last lesson

1 Activity 1: Mimic the life of bees in a colony

outdoor

This activity should take **40 minutes**.

1. Distribute the hats and various props to the performers according to Table 5.2 (see previous lesson).
2. Take the pupils outside. Find a large open space to perform the play and ask the observers to sit in a circle around it. Leave a gap in the circle for the performers to enter and leave the stage.
3. Read the script (on the next page) aloud and help the performers practise the play.
   - » Performers should run onto the stage when they are mentioned in the script.
   - » The performers should practise twice with the teacher to familiarize themselves with the play.
   - » The observers should watch the rehearsals but do not need to answer the questions (written in their exercise books) for now.
4. The performers will perform the play two or three times in front of the observers.
5. Encourage the observers to watch the play, review the questions in their notebooks and write down their answers during the play. You may wish to invite other teachers and pupils to watch the final performance of the play.

Script: *The life of bees*

T = Teacher

T: More than 130 million years ago, the Earth was overgrown with **ferns** and **conifers**.

- [FERNS and CONIFERS enter, stand still and move their arms in the breeze.]

T: Green and brown are the main colours in the forest. There are no colourful or fragrant flowers. The **wind** blows.

- [The WIND performers enter, cup their hands around their mouths, and blow.]

T: Pollinated by the wind, the plants multiply and younger plants grow. But there are not many types of plants. The forest looks the same everywhere.

T: But then the plants come up with a trick: they start developing **bright colours**, fragrances and sweet nectar to make themselves different and more appealing to animals, such as insects.

- [FLOWERING PLANTS enter, squat down, and then stand up (as if growing) and move their arms when the wind blows.]

T: Insects become aware of these new flowering plants and begin collecting their sweet nectar and pollen. One of these is a **hunting wasp**.

- [FIRST BEE enters and starts investigating the flowering plants.]

T: Having tasted nectar from the flowers, the hunting wasp starts feeding on it.

T: As time goes by, the hunting wasp gives rise to bees. This is how the **honeybee** comes about, more than 80 million years ago.

- [FIRST BEE switches hats and continues to investigate the flowering plants.]

T: Honeybees and flowering plants become more numerous. The forest is now more colourful and filled with many more plant species. **Forager honeybees** find many food sources, searching for and collecting nectar and pollen.

- [FORAGER BEES enter, bringing a box to represent the nest, which they place on the floor. They then run from one flower to another, collecting nectar with their straws or with a finger in front of their mouths.]

T: The honeybees collect pollen on their hind legs and carry nectar in their honey stomachs to the nest. Suddenly, though, **bee-eating birds** appear.

- [BEE-EATING BIRDS enter and chase the FORAGER BEES, who try to avoid them and fly to the nest.]

T: The forager bees must be careful they are not eaten by the birds. Fortunately, most foragers reach the nest. There, they meet **guardian bees**. These guard the nest against predators such as birds, hornets and wasps, which want to invade the nest to steal honey, pollen, bee larvae and even adult bees. In an emergency, the guardian bees will stab intruders with their poison stingers.

- [GUARDIAN BEES enter and stand in front of the nest to defend it.]

T: Now, the forager bees hand over their harvest to the **house bees**, who convert it into honey and store it in honeycomb.

- [HOUSE BEES enter and use their straws (or a finger in front of their mouths) to receive nectar from the FORAGER BEES and then give it to another bee in the nest.]

T: Many bees work together and help keep the bee colony thriving. **Cleaner bees** clean the brood cells from which they have just hatched.

- [CLEANER BEES enter and start cleaning the nest with their towels.]

T: **Caretaker bees** feed honey to the larvae in the brood cells.

- [CARETAKER BEES enter and pretend to feed bee larvae inside the nest, as if they were babies.]

T: Other **bees sweat wax** out of their sides and build the honeycomb and brood cells.

- [WAX PRODUCER BEES enter and flap their arms like wings, holding the yellow pieces of paper representing wax.]

T: The **queen** lays small, elongated eggs in the brood cells.

- [QUEEN enters and pretends to lay eggs in the nest.]

T: New worker bees – all females – will develop from these eggs after **19–20 days**.

- [A SIGN CARRIER enters and holds up the sign, "Worker bees = 19–20 days".]

T: There are also bigger brood cells. Inside these, the male bees, or drones, grow for **24 days**.

- [The second SIGN CARRIER enters and holds up the sign, "Drone bees = 24 days".]

T: One brood cell is especially big and long. The larva in this cell is fed with a special juice called royal jelly. A new queen is born out of this cell after only **14 days**.

- [The third SIGN CARRIER enters and holds up the sign, "Queen bee = 14 days".]

T: Meanwhile, the only male bees in the nest, the **drones**, are resting, eating and growing strong. Soon, they will be ready to fly away to mate with a new queen from another colony.

- [DRONES enter and lie down near the nest, pretending to eat a huge feast.]

T: The bee colony grows and grows. Up to 80 000 bees can live together in a single nest. This community has developed skills that individual bees cannot master. Together, a bee colony is a highly efficient social unit.

T: The end.

At the end of the play, the performers gather together and bow to the observers, who applaud the performance.

Preparation for the next lesson

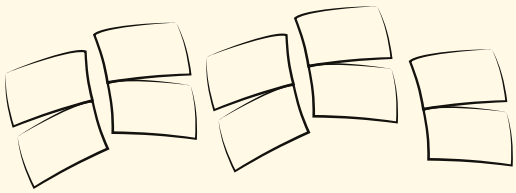
Tell the pupils that they will discuss what they have learned from the play in the next lesson. Ask the observers to prepare to answer the questions written in their excercise books. Ask all the pupils (including the performers) to think of other questions about bees, using what they have learned. They should write these questions in their exercise books. You will need ten pieces of A4 paper, divided in half, for the next lesson.

LESSON 18

What did you learn from the role play?

18

Required materials



10 PIECES OF PAPER
DIVIDED IN HALF

1 Activity 1: Discuss the life of bees in a colony

indoor

This activity should take **25 minutes**.

Tip: Remind the observer group that they will use the same questions (see below) assigned to them before the play.

1. Write the following questions on the board.
   - When did honeybees first appear on Earth?
   - What do honeybees eat?
   - Where do honeybees live?
   - What are the different roles played by honeybees in a colony?
   - What kinds of tasks do worker bees do?
   - How is wax produced?
2. Ask the observer group to relate what they have learned during the play by answering the questions above.
3. The observers will use the notes they made in their exercise books (or on pieces of paper) during the play to answer the questions.
4. Write a summary of the answers on the board and add information where there are gaps. Ask all the pupils to copy the answers into their exercise books.

5. Use additional questions to guide the discussion (below are examples). Ask the pupils to write the answers in their exercise books during the discussion.
   - Who do you think is the most important type of bee in a nest?
   - What do you think would happen if one caste of bee disappeared from a colony?

2 Activity 2: Reflect on what has been learned

indoor

This activity should take **15 minutes**.

1. Ask the pupils to review the questions they have prepared for the lesson (they should be written in their exercise books).
2. You will use the "paper ball" method to encourage active participation, as follows.
3. Take a sheet of the divided paper and write down a question about bees. For example, how many legs does a bee have?
4. Crumple the sheet of paper into a ball and throw it to a pupil.
5. The pupil opens the ball, reads the question aloud, and gives an answer. Give this pupil a blank piece of paper.
6. On this new sheet of paper, the pupil writes down one of the questions they have prepared ahead of the class and wraps it around the first piece of paper to form a bigger ball, which they then throw to another pupil.
7. The next pupil reads and answers the new question aloud, and the process continues.
8. The ball grows.
9. Conclude the lesson by **explaining:**
   - that the number of bees in the world is declining;
   - this is because their habitats (such as forests) are being destroyed, pesticides are poisoning them, and climate change is increasing the temperature and changing the times at which plants flower; and
   - World Bee Day is celebrated every year on 20 May to raise awareness of the important role of bees in our lives and the need to protect them.

Preparation for the next lesson

Keep the hats for the next chapter.

Notes

[1] **FAO**. 2018. *Why bees matter*. The importance of bees and other pollinators for food and agriculture. www.fao.org/3/i9527en/i9527en.pdf

[2] **The British Beekeepers Association**. 2022. Bee Facts. In: *The British Beekeepers Association*. Cited 23 December 2022. www.bbka.org.uk/pages/faqs/category/bee-facts

[3] **FAO**. 2020. FAO's Global Action on Pollination Services for Sustainable Agriculture. In: *Food and Agriculture Organization of the United Nations*. Cited 23 December 2022. www.fao.org/pollination

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CHAPTER 6

Pollination and bee products

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Overview

In this chapter, the pupils will learn about the multiple benefits of beekeeping – such as pollination and bee products – through a matching game and a demonstration of how bee pollination occurs.

Objectives

By the end of the chapter, the pupils will be able to:

- identify bee products and their uses and benefits;
- describe how pollination occurs; and
- explain why pollinators are important for healthy ecosystems, such as forests, and the production of food crops.

Background information

What is pollination?

Pollination is the transfer of pollen from the male part of a flower to the female part of a flower. The flowers may be on the same plant or on different plants of the same species. Pollination is essential for the sexual reproduction of plants.

Some plants use the wind to disperse their pollen, but other plants need animal pollinators. Bees are important pollinators, as are other invertebrates, such as many species of moths, flies, wasps, beetles and butterflies. Important vertebrate pollinators include certain nectar-feeding bats, monkeys, rodents, lemurs and birds (such as parrots).

Pollinators are attracted to the bright colours and powerful scents of flowers. As a pollinator "harvests" a flower, it collects pollen on its legs, head, wings and other body parts (depending on the kind of animal it is). When it visits another flower, it transfers some of the pollen from the first flower to the second.

The most important pollinators in the United Republic of Tanzania are honeybees, other bee species, flies, wasps, moths, butterflies, beetles, ants and birds.

Why are pollinators important for the environment, the forests and our lives?

Pollinators are important for the reproduction of many trees and other forest plants, and thereby help maintain forest biodiversity. The more flowers that are pollinated on a tree, the more fruit and seeds the tree will produce.

Pollinators are essential for many fruit and vegetable crops. Three out of every four crops in the world that produce fruit or seeds that people eat depend at least partly on animal pollinators such as bees, bats, birds and butterflies.[1] In East Africa, honeybees pollinate important food plants such as maize, cucumber, pumpkin, melon, sunflower, apple, almond and citrus.[2] The value of crop products worldwide that depend on the pollination services of insects is estimated at between USD 235 billion and USD 577 billion per year.[3]

Some pollinators specialize in pollinating certain plant species, which is why it is important to protect all pollinator species. Without this diversity, some plants would be unable to reproduce, and we would lose them (and possibly also the pollinators). Today, however, 40 percent of invertebrate pollinator species – particularly bees and butterflies – are under threat.[4]

Without pollinators, human beings and terrestrial ecosystems would not survive.

Picture 6.1. A bee visiting a flower

Picture 6.2. A bird visiting a flower

What products come from honeybees?

Honeybees are excellent pollinators, and they also produce many things that are important for our lives, including the following:

- **Honey** is the main product obtained from honeybees, and it offers many health benefits. For example, it is a source of antioxidants; can be used to soothe sore throats; helps us digest food; heals wounds; and has antibacterial and antifungal properties and immune-boosting benefits. Conversely, honey can carry harmful bacteria, such as those that cause botulism, which is particularly dangerous for babies (and is the reason why honey should never be given to children younger than 1 year old).
- **Royal jelly** is a creamy white juice produced by bees to feed all bee larvae for the first 3 days of their lives and queen bees for their entire lives. It has powerful antimicrobial properties, and it can also reduce high blood pressure and blood sugar in people. On the other hand, it can cause allergic reactions.
- **Beeswax**, which is produced by young bees, can be made into candles, added to cosmetics, and used as a food coating agent.
- **Propolis** is a sticky substance that honeybees make by mixing their saliva with tree sap and other liquids they collect from plants. Propolis has anti-inflammatory and antirheumatic properties, and can be used for pain relief and to reduce cholesterol.
- Like propolis, **bee venom** has anti-inflammatory and antirheumatic properties, and can reduce cholesterol. It can trigger allergies in people, however, when they are stung.

Bee bread and bee brood are two other products from bees.

The country has the potential to produce 138 000 tonnes of honey and 9 200 tonnes of beeswax per year. Despite this existing potential, it produces only 30 400 tonnes and 1 830 tonnes of honey and beeswax per year respectively.[5]

Picture 6.3. Freshly harvested honey

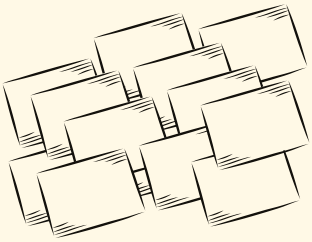
Picture 6.4. Propolis

LESSON 19

What do we use bee products for?

19

Required materials



30 MANILA CARDS

1 PAIR OF SCISSORS
to cut the manila cards (OPTIONAL)

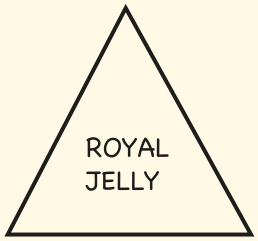
Preparation for the lesson

- Take six manila cards and, on five of them, write the names of five bee products (e.g. honey, royal jelly, beeswax, propolis and bee venom). On the sixth card, write pollination. Cut the manila cards into different shapes, such as a circle, a triangle, a square, a rectangle, a star and a diamond.
- On 24 manila cards, write one benefit or risk per card related to the five bee products and the pollination service (Figure 6.1). These cards should be cut out in the same shapes as the product or service cards you prepared above. For example, if the "honey" card is a square, all the cards related to the benefits and risks of honey should also be squares.

1. HONEY

- Heals wounds.
- Is a source of substances that help protect the body.
- Soothes sore throats.
- Helps us digest food.
- Has antibacterial properties.
- Has immune-boosting benefits.
- Can carry harmful bacteria, such as those that cause botulism (which is dangerous for babies and the reason why honey should never be given to children younger than 1 year old).

2.

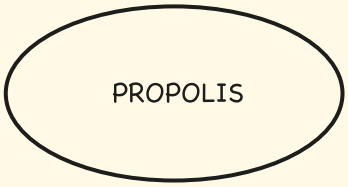


- Is an antimicrobial.
- Reduces blood pressure and blood sugar.
- Can cause allergic reactions, such as asthma and anaphylaxis.

3.

- Is used to make candles.
- Is added to cosmetics, paints and polishes.
- Is used to encourage bees to build orderly honeycombs in hives.
- Is used as a separating and coating agent for food and pills.

4.



- Has anti-inflammatory properties.
- Is used as a pain reliever.
- Reduces cholesterol.

5.

- Is used as a pain reliever.
- Has anti-inflammatory properties.
- Reduces cholesterol.
- Can trigger bee venom allergies.

6.

- Is essential for biodiversity.
- Helps ensure food production for people.
- Helps ensure food for plant-eating animals.

Figure 6.1. The benefits and risks of honeybee products

1 Activity 1: Match bee products and their benefits

outdoor This activity should take **40 minutes**.

1. Hand the bee product and pollination cards you prepared to six pairs of pupils.
2. Split the rest of the class into 25 groups and hand each group one of the 25 risk or benefit cards.
3. Make sure all the pupils are involved.
4. Explain to the pupils that they will now learn more about the most important bee products and their uses.
5. Explain to the pupils that there are two types of cards – one type with a bee product written on it, and one type that describes a benefit or risk of that bee product. Tell the pupils that one set of cards describes a bee service rather than a bee product.
6. Explain that, when you give the signal, those pupils holding the product or service cards should stand still in different areas in the schoolyard. The pupils holding the benefit or risk cards must try to match them to the appropriate product or service card. Tell them to stand by the pupils with the product or service card if they think they have a match. If the cards are cut into different shapes, do not tell the pupils because they will have more fun locating the correct match.
7. By the end of the game, the pupils holding the benefit or risk cards should be forming groups around the pupils holding the matching product or service cards.
8. When the pupils have formed these groups, give a signal to end the game.
9. Read out the correct descriptions for each product or service. Allow any pupils who are in the wrong group to join the correct group.
10. Ask a pair of pupils with one of the bee product cards to bring the cards to you. Read aloud the descriptions that match the product cards and ask the pupils holding the correct descriptive cards to bring those to you as well.
11. Hold up each card and ask all the pupils to write the name of the bee product and its uses, qualities, benefits and risks in their exercise books.
12. Repeat the same steps for each bee product card.
13. Finally, ask the pair of pupils holding the pollination card to come forward. Read aloud the descriptions that match the pollination card and ask the pupils holding the correct descriptive cards to bring those to you as well.
14. Hold up the cards and ask the pupils to write the name of the bee service and its uses, qualities, benefits and risks in their exercise books.
15. Point out to the pupils that pollination is a service provided by bees (not a product).
16. When you are back in the classroom, use adhesive tape to stick the bee product cards and the pollination card on the classroom wall, with the matching descriptive cards around them, so that the pupils can continue to view them.
17. Tell the pupils that bee bread and bee brood are other two products from bees.

Preparation for the next lesson

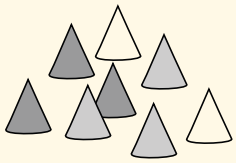
Ask 12 volunteers to each bring a clear container or glass jar to the class. Ask four other pupils to each bring in a tablespoon. As another option, bring these items in yourself.

LESSON 20

Play a honeybee pollinator game

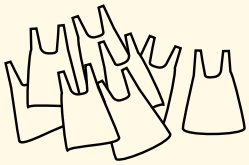
20

Required materials

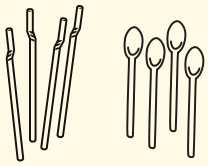


8 COLOURED HATSMADE OF NEWSPAPER
(see chapter 5)

4 YELLOW/BROWN HATS
(see chapter 5)

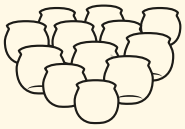


12 SMALL COTTON OR PLASTIC BAGS



4 REED STRAWS OR TABLESPOONS

ENOUGH SAND FOR EACH COTTON OR PLASTIC BAG



12 GLASS JARS

1 BOTTLE WITH JUICE OR WATER

AT LEAST 12 PIECES OF FRUIT OR 12 NUTS, SUCH AS CASHEWS
(ideally, there would be one nut or piece of fruit per pupil)

1 Activity 1: Mimic the work of a honeybee pollinator

outdoor

This activity should take **40 minutes**.

1. Ask the pupils if they know anything about pollination. Collect some answers.
2. **Explain:**
   - » In most animals and plants, sperm cells must connect with an egg to reproduce. When this happens, it is called fertilization. In plants, the sperm cells are in the pollen and the egg cells are in the ovary of the plant. If the two combine, the fruit that develops will contain seeds for growing new plants.
   - » For animals to multiply, they have to look for a partner so the sperm can connect with an egg. But how do plants manage to get pollen – a plant's version of sperm – into their ovaries? They cannot physically move around to look for a partner. Wouldn't a courier be useful?

- Plants have developed flowers with many bright colours, fragrant scents and sweet nectar to attract pollinators like honeybees. These pollinators act like couriers, moving pollen between flowers. They obtain nectar, and some of the pollen, as a reward.
- How exactly do honeybees pollinate plants?

3. Tell the pupils that they will learn through a demonstration.
4. Tell the 12 pupils who brought in the glass jars or plastic containers that they will be actors in the pollen courier activity. Tell the other pupils that they will be observers.
5. Tell the 12 actors that their aim is to collect as much nectar as they can.
6. Eight of the actors should put on a coloured hat. Tell them they now represent flowers.
7. Four of the flower actors will each carry a small bag containing sand, which represents pollen. They will also carry a jar filled with juice or water, which represents nectar.
8. The other four flower actors will each carry an empty bag and an empty jar. These will be filled by the honeybees during the activity.
9. The remaining four pupils should each put on a yellow/brown hat. They will represent the pollinators, which are the honeybees. They will each carry a small empty bag and an empty jar with a straw or a tablespoon. They will use the straw or tablespoon to suck up or scoop up the water or juice from the flowers (which are carrying jars full of water or juice). Remind the pupils that the spoon represents the bee's proboscis, which it uses to suck up nectar from flowers. They will put the water or juice they get into their jars.

» **COLOURED FLOWERS (A)**	Four pupils, each with a bag of sand (representing pollen) and a jar of juice or water (representing nectar).
» **FLOWERS TO BE POLLINATED (B)**	Four pupils, each with an empty bag and a jar full of juice or water (representing nectar).
» **HONEYBEES**	Four pupils, each with one small empty bag and one straw or tablespoon.

10. Each coloured flower (A) will take a handful of sand from their own bag and put it into a honeybee's bag.
11. Each honeybee will use the straw or the tablespoon to take juice or water from the jar of one of the flowers (A).
12. The honeybee will then run to one of the flowers that needs to be pollinated (B).
13. Flower B will take a handful of sand out of the honeybee's bag and put it into their own bag.
14. The honeybee will use the straw or spoon to take juice or water from the jar of flower B and put it into their own jar.
15. Start the activity and allow it to run for about 10 minutes.
16. After stopping the activity, show the class how much sand is in the bags of the B flowers and how much juice or water is in the jars of the honeybees.
17. Ask some of the observers to explain what the honeybees were doing.
18. **Explain:** Honeybees are "couriers" that carry messages – pollen – from one flower to another. They receive nectar and some of the pollen as their reward. We need pollination to produce fruit and nuts.
19. If available, offer a piece of fruit or a nut to each pupil.

LESSON 21

What is pollination?

21

1 Activity 1: Reflect on the importance of pollination

indoor

This activity should take **40 minutes**.

1. Remind the pupils about the previous activity. Draw a simple model of pollination on the board, as shown in Figure 6.2, and ask the pupils to copy it into their exercise books. If they have their pupils' books, they will also find the drawing there.

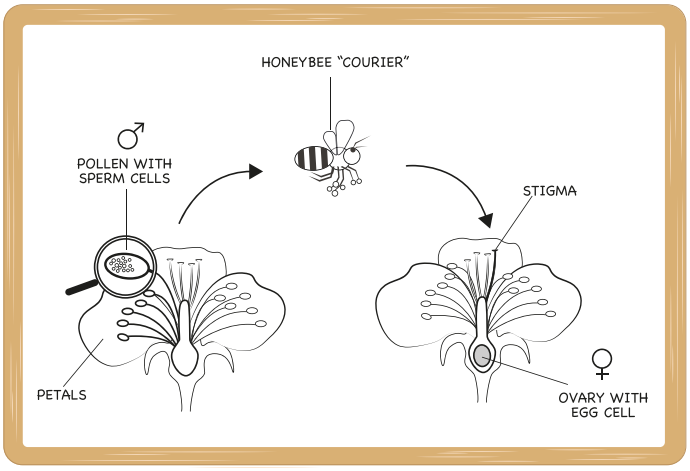


Figure 6.2. A simple model of pollination

2. Tell the pupils that the process of pollination is extremely important for a healthy forest. Ask the pupils:
   - Why do plants need pollinators?
   - » **Answer:** Pollinators take pollen from one flower to another. The sperm in pollen fertilizes the flower's ovary, enabling it to develop into fruit. The fruit contains seeds, from which the next generation of the plant will grow. Using pollen from different plants creates more diversity. In the long run, this helps species survive.

3. Tell the pupils you will now dictate some text aloud, and they should write it in their exercise books. Explain that some words are missing from the text, and they will need to guess the missing words. When you reach a blank space, pause and ask the pupils to volunteer answers before revealing the correct one. If the pupils have their pupils' books, they will also find the text there (with the key words missing).

Pollination

A bee flies from flower to flower to collect _____ and _____.

The bee sucks up nectar with its _____.

Inside a flower, pollen sticks to the bee's _____. When the bee flies to the next flower, some pollen comes off the bee and lands on the flower. In this way, the _____ is fertilized and will develop _____, from which new plants can grow.

This is called _____.

It is important that there are many species of _____ like bees, wasps, ants, moths, beetles, bats and birds because not every pollinator species can pollinate every type of flower. Without this variety, there would be fewer plant species.

Solutions for the teacher

Pollination

A bee flies from flower to flower to collect nectar and pollen.

The bee sucks up the nectar with its proboscis.

Inside a flower, pollen sticks to the bee's body. When the bee flies to the next flower, some pollen comes off the bee and lands on the flower. In this way, the flower is fertilized and will develop seeds, from which new plants can grow.

This is called pollination.

It is important that there are many species of pollinators like bees, wasps, ants, moths, beetles, bats and birds because not every pollinator species can fertilize every type of flower. Without this variety, there would be fewer plant species.

4. Finally, ask the pupils:
   - Why are honeybees important for the health and well-being of forests?
   - » **Answer:** Honeybees are important pollinators of trees and other forest plants. The more flowers that are fertilized on a tree, the more fruit and seeds will be produced. Pollinators such as honeybees help many plant species reproduce in forests, and this helps keep forests healthy.
   - Why are forests important for honeybees?

- **Answer:** Forests are natural habitats of honeybees. They provide honeybees with space for their colonies, as well as many flowering plants from which they can obtain nectar and pollen.

5. Write the correct answers above on the board and ask the pupils to copy them into their exercise books.
6. Conclude the lesson by telling pupils that bees are not the only pollinators.
7. **Explain:**
   - Many other insects act as pollinators, such as moths, flies, wasps, beetles and butterflies.
   - Some vertebrates are also important pollinators, such as bats, several species of monkey, rodents, lemurs and birds such as parrots.
   - Not every pollinator can pollinate every type of flower. That is why it is important to protect all pollinator species. Without this variety, some plants would be unable to reproduce, and we would lose them (and maybe also the pollinators that depend on those plants for food).

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Preparation for the next lesson

Ask the pupils to each bring a small spoon to the next lesson. As another option, bring these items in yourself.

Notes

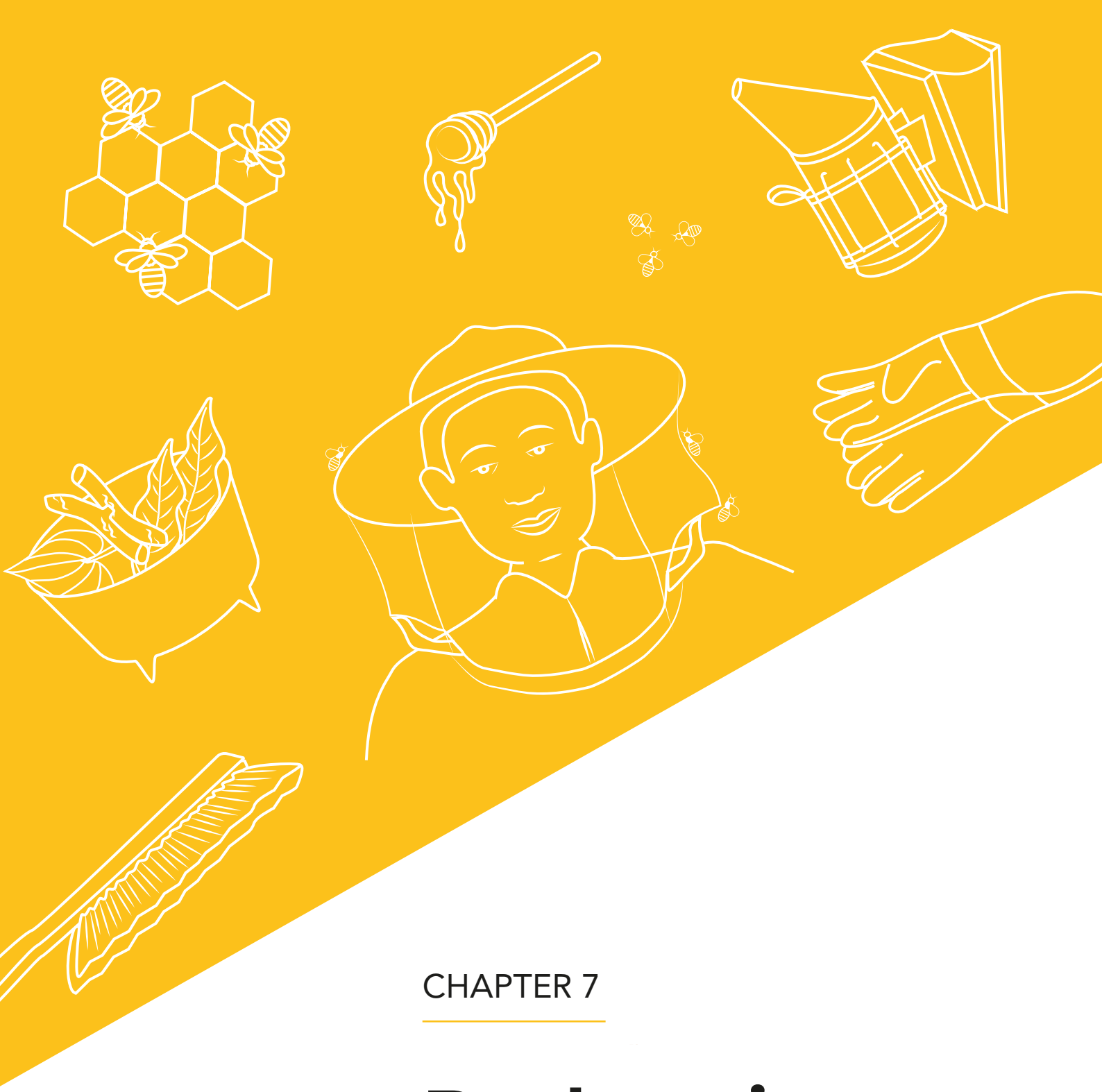
[1] **FAO**. 2016. Pollinators vital to our food supply under threat. In: *Food and Agriculture Organization of the United Nations.* Cited 23 December 2022. www.fao.org/news/story/it/item/384726/icode

[2] **BioNET-EAFRINET**. 2022. Factsheet: Apis mellifera (The Honey Bee). In: *BioNET-EAFRINET*. Cited 23 December 2022. https://keys.lucidcentral.org/keys/v3/eafrinet/bee_genera/key/african_bee_genera/Media/Html_eafrica/Apis_mellifera_(The_Honey_Bee).htm

[3] **FAO**. 2016. Pollinators vital to our food supply under threat. In: *Food and Agriculture Organization of the United Nations.* Cited 23 December 2022. www.fao.org/news/story/it/item/384726/icode

[4] **FAO**. 2016. Pollinators vital to our food supply under threat. In: *Food and Agriculture Organization of the United Nations.* Cited 23 December 2022. www.fao.org/news/story/it/item/384726/icode

[5] **Street, W. M.** 2021. *Guidelines for establishment and management of bee reserves and apiaries in Tanzania.*



CHAPTER 7

Beekeeping

Overview

In this chapter, the pupils will learn about various methods of beekeeping in the United Republic of Tanzania, including the equipment used. They will learn about the various phases of a beekeeper's year.

Objectives

By the end of the chapter, the pupils will be able to:

- explain different beekeeping models;
- identify the equipment and tools used by beekeepers;
- describe the various phases of a beekeeper's year; and
- understand why beekeeping is important.

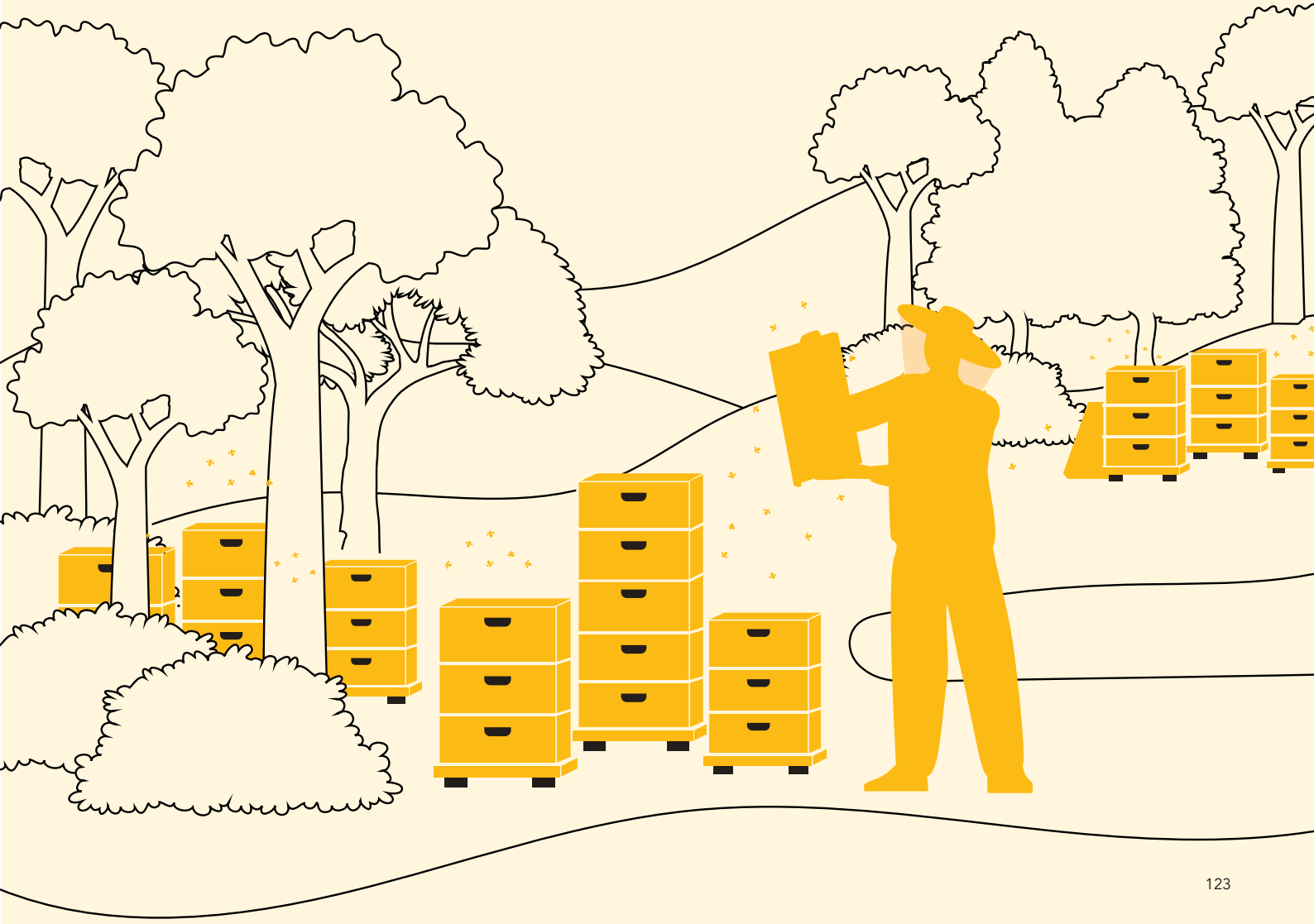
Background information

What is beekeeping?

Beekeeping is the occupation of keeping and managing social bees for their honey and the other products that they produce (see Chapter 5 and Chapter 6). Beekeepers keep bee colonies in human-made hives and take care for them. This ensures that the colonies continue to produce honey and other bee products over time. In contrast, "honey hunters" gather honey from wild bee colonies. They destroy the colonies when they harvest them.

Beekeeping produces food, medicines, cosmetics and other bee products. Since ancient times, people have used bee products such as honey, pollen, propolis, royal jelly and bee venom as treatments for various ailments, and they are still considered part of traditional and complementary medicine. In Africa, beekeeping has been practised for thousands of years, especially in the Sahel region.

Some beekeepers work on large industrial farms, and others work for smaller businesses and sell their bee products in local markets. In both cases, successful beekeeping has several requirements, such as sufficient habitat (including forest) for melliferous plants (plants that produce substances that can be collected by insects and turned into honey); water sources; the capacity to manage bee colonies; and knowledge of and access to markets for bee products.



What do beekeepers do?

Beekeepers ensure that the hives they manage are healthy and productive. A hive is a container that can host a honeybee colony, mimicking the cavity that a wild swarm would naturally occupy. In the United Republic of Tanzania, beekeepers use two types of hives:

- **Local-style hives:** These are hives made from locally available materials. Some of the types of hives used commonly in the United Republic of Tanzania include:
  - **Log hives:** Log hives are constructed from the trunk of a tree. Beekeepers chisel the log to make a hollow inside and then plug both sides of the log, leaving one side with entrance holes through which bees can enter.
  - **Bark hives:** Bark hives are made from the bark of live trees and joined using wooden pegs. The open sides are closed with caps either made from curved wood, or woven reeds (or grass). One side has entrance holes for bees to enter the hive.

  The log and bark hives are then suspended from a tree branch about 6 m (metres) above the ground. Beekeepers cut out the ripe honeycombs by opening one side of the hive or lifting up its top half. Log and bark hives are made with locally available materials, making them a low-cost option.

- **Modern (top-bar) hives:** Top-bar hives are constructed out of wooden planks. They consist of boxes containing individual bars of wood laid across the top of the hive, from which bees build their combs. These hives have removable combs, which enable beekeepers to better control the bees, monitor the growth of colonies and choose which combs to harvest without harming the bees or the combs. Beekeepers who use top-bar hives have plenty of work to do, including building the wooden boxes (out of planks) that serve as the hives, gathering bee swarms to populate the hives, cleaning the hives, replacing the honeycombs inside the hives, and keeping healthy bees for pollination and the production of honey and other bee products. This type of hive is highly effective for the production and harvesting of bee products.

Picture 7.1. Local-style hives

Picture 7.2. Modern (top-bar) hives

To start their beekeeping activity, beekeepers have to catch a bee swarm and install it in a human-made hive. There, the bees will create a new bee colony which, if well managed, will live for a long time while producing honey and bee products.

Beekeeping can be dangerous if done without protective gear because bee stings can produce severe and potentially fatal allergic reactions (and are also painful). It is important, therefore, to wear protective clothing covering the entire body when dealing with bees. The equipment of a beekeeper should include the following:

- **Gloves.** Beekeeping gloves are made of leather or other tough, flexible material. Gloves protect the beekeeper's hands from stings.

- **Suit, with veil.** A beekeeper's suit (sometimes called a "bee suit") is a full set of overalls with long sleeves and trouser legs. It is designed to protect beekeepers as they remove honey from hives and do other work near hives. Bee suits come with hats and veils to protect the head and neck. The veil can be zipped to the bee suit so no bees can get in.
- **Smoker.** A bee smoker is a stainless steel device with bellows (for blowing air). It is used to puff smoke over a hive to calm the bees and make them less aggressive. The most common material used in the United Republic of Tanzania for the smoke is dry cow dung, which is not toxic to the honey and bees.
- **Smoking materials.** Various dry natural materials, such as pine needles, herbs and straw, can be used to produce smoke in a bee smoker.
- **Hive tool.** Beekeepers use blunt metal tools called hive tools to separate the wooden hives (which are often stacked on top of each other), if they are stuck together. Hive tools are also used to scrape propolis from the interior of the hives.
- **Bee brush.** Soft bristled brushes are used to gently remove bees from the combs during harvesting. When used properly, a bee brush does not injure the bees.

How does beekeeping contribute to livelihoods and the environment?

The beekeeping industry contributes substantially to the economy of the United Republic of Tanzania. It employs more than 2 million women and men in beekeeping and related jobs, such as producers, processors, packers and salespeople.[1] More than 50 percent of the land of the United Republic of Tanzania is covered by forests suitable for beekeeping. The Ministry of Natural Resources and Tourism published a national beekeeping policy in 1998 and the Beekeeping Act in 2002 to support the country's beekeeping.

When good beekeeping practices are applied, beekeeping contributes to optimal health for humans, honeybees and the environment. In addition to supporting many livelihoods directly, beekeeping adds significantly to agricultural production (see Chapter 5 and Chapter 6). It also helps conserve forests because beekeepers must protect melliferous plants as a food supply for their bees, and forests are home to many such plants. Another benefit of beekeeping is that elephants avoid places with beehives, which can help in reducing human–wildlife conflicts. By creating "natural fences" with hives around human settlements, beekeeping can help keep elephants away.

Picture 7.3. Honey extraction

Picture 7.4. Packaging honey

LESSON 22

What does a beekeeper do?

22

Required materials

OPTIONAL: HONEY
enough to allow each pupil to taste it

OPTIONAL: WOODEN SPATULA (OR SPOON)
1 for each pupil

ADHESIVE TAPE

1 PAIR OF SCISSORS

Preparation for the lesson

Cut out the pictures showing the honey-harvesting steps taken by beekeepers using modern (top-bar) hives in the United Republic of Tanzania on the pages at the end of the chapter. You will distribute these to the pupils in Activity 2. If the pupils have their pupils' books, they will find the pictures there, and there is no need to cut in the pictures out this book.

1 Activity 1: Interpret a poem

indoor

This activity should take **10 minutes**.

1. Tell the pupils that you will read a poem to the class. Ask them to listen carefully. Read the poem aloud, slowly. Then, read it aloud again.

   What is a jar of honey worth?
   by Ulrike Schuth, after Josef Guggenmos

   Will you allow me to make a wish?
   I want some honey for my dish.

What does it cost?
I'm willing to pay.
My money is for good things, anyway.

You want something good for your money?
You will get the world's best, with honey.
You will buy pure sunshine.
You will buy pure health!
There's nothing better than honey, for wealth.

If bees charged a fee by the hour
As they fly from flower to flower
At 12 000 hours per jar
And 5 dollars an hour I'm expecting
For those hard-working bees gone collecting.

So what should we charge for their skill?
60 000 dollars per jar, here's the bill.

2. Ask the pupils whether they understand the poem. Go through it again, line by line.
3. Encourage the pupils to share their thoughts and experiences by asking the following questions (and supply the answers if they can't guess):

   ► What do you think is the main message of this poem?

   » **Possible answer:** Honey is a valuable forest product because it has many uses. You can make money by producing honey.

   ► Does the poem say anything about why the cost of honey is so high?

   » **Possible answer:** Yes, because it takes so much time for bees to make honey. The bees have to work hard to collect nectar from flowers and to store it as honey. The poem compares the working time of a bee with that of a human.

   ► Why do you think the poem tells us that honey is "pure sunshine"?

   » **Possible answer:** Because flowers need sunlight to produce the nectar that bees use to produce honey.

   ► Why do you think honey is "pure health"?

   » **Possible answer:** Because honey has many health-promoting properties.

4. Ask the pupils to think about the value of the work that bees do and the honey they produce. Summarize by saying that beekeeping can provide income, protect natural resources and contribute to people's diets and well-being.
5. If honey is available, invite the pupils to line up with their spoons or spatulas and give each a small serving of honey. If some pupils have forgotten to bring a spoon or spatula, provide them with one of your spares.

2 Activity 2: Learn the difference between honey hunting and beekeeping

indoor

This activity should take **10 minutes**.

1. Tell the pupils that honey can be either harvested in the wild or produced in human-made hives.
2. The activity of harvesting honey in the wild is called "honey hunting". The activity of producing honey in human-made hives is called "beekeeping".
3. Make two columns on the board, one headed, "Honey hunting" and the other, "Beekeeping".
4. Explain the differences between honey hunting and beekeeping, which you will explain as follows:

HONEY HUNTING	BEEKEEPING
• Honey hunters gather honey from wild bee colonies. • Bee colonies are destroyed when the honey is harvested. • Sometimes, the tree holding the hive is cut down to help in harvesting the honey. • Sometimes honey hunters leave open fires that can destroy forests.	• Beekeepers keep bees in human-made hives and care for them. • The bee colony is not destroyed when the honey is harvested. • No trees are cut down to harvest the honey. • Beekeepers wear protective clothing that enables them to handle bees safely and avoid being stung.

Figure 7.1. Difference between honey hunting and beekeeping

5. If there is time, encourage the pupils to reflect on the differences between honey hunting and beekeeping by asking the following questions:
   - Out of honey hunting and beekeeping, which provides the most honey?

     Answer: Beekeeping. In honey hunting, the bee colony producing the honey is destroyed when the honey is harvested. In beekeeping, the bee colonies are managed to ensure that they continue to produce honey and other bee products over time.

   - Which is less dangerous for human safety?

     Answer: Beekeeping. Beekeepers wear protective clothing against bee stings.

   - Which is better for the environment?

     Answer: Beekeeping. If properly performed, bees in managed hives are not harmed during harvesting, and no wild bee colonies are destroyed.

3 Activity 3: Discuss the activities carried out by a beekeeper

indoor

This activity should take **20 minutes**.

1. Tell the pupils that beekeeping is the occupation of keeping and managing bee colonies for their honey and the other products they produce.
2. Beekeepers keep bee colonies in human-made hives and take care of them. This ensures that the colonies continue to produce honey and other bee products over time.
3. Human-made hives are containers that host honeybee colonies.
4. Tell the pupils that there are two methods of beekeeping: a traditional method that uses local-style hives, and a more recent method that uses modern (top-bar) hives.
5. Make two columns on the board, one headed, "Beekeeping with local-style hives" and the other, "Beekeeping with modern (top-bar) hives".
6. Ask the pupils to copy into their exercise books the differences between the two, as described below.

BEEKEEPING WITH LOCAL-STYLE HIVES	BEEKEEPING WITH MODERN (TOP-BAR) HIVES
Local-style hives are made of curved tree trunks (log hives) or with bark taken from tree trunks (bark hives). They are hung from tree branches about 6 metres above the ground, so the beekeepers must climb the tree to harvest them.	Top-bar hives are made of wooden planks and consist of boxes containing individual bars of wood laid across the top of the hive from which bees build their combs. Top-bar hives are installed close to the ground (sometimes on benches).

Figure 7.2. Difference between beekeeping with log hives and beekeeping with top-bar hives

7. Organize the pupils into eight groups of equal size. Give each group one of the photos you cut out showing the honey-harvesting steps implemented by beekeepers using top-bar hives in the United Republic of Tanzania.
8. Ask the pupils to discuss the photos in their groups and guess what the beekeepers are doing in each photo. Each pupil should write the answer in their own exercise book.
9. Ask each group, one at a time, what their photo shows, starting with the group with the step 1 picture and proceeding with the following steps. One pupil from each group should hold up their photo (or say its number) so that all pupils can see it and then answer the question. Take the photo (or its number) and stick it (or write it) on the board, in the correct order.
10. Explain briefly what is illustrated in each photo (see descriptions on pages 130 and 131).

Picture 7.5. Remove the bees from the hive

STEP 1. Calm the bees in the hive
Beekeepers use bee smokers that puff smoke over their hives to calm the bees. Dry pine needles, herbs, straw and other organic matter can be used to generate smoke in a bee smoker.

Picture 7.6. Open the hive

STEP 2. Open the hive
The beekeepers carefully open the hive by removing the top of the box.

Picture 7.7. Extract the honeycombs

STEP 3. Extract the honeycombs
The beekeeper extracts the honeycombs. Bee brushes are used to gently remove bees from the surface of the honeycomb. These brushes have long, soft bristles, which are gentle enough to remove live bees from delicate combs, frames, equipment and even beekeepers without harming the bees. See that the beekeeper in the photo is holding a "bar" with the honeycomb attached. This is the "top bar" that gives its name to the hive type.

Picture 7.8. Check if honey is ready to be harvested

STEP 4. Check if honey is ready to be harvested
The beekeeper checks whether the honeycombs are ready to be harvested. Only those honeycombs that are full of honey will be harvested.

Picture 7.9. Harvest the honey

STEP 5. Harvest the honey
The beekeeper removes the full honeycombs from the hives and puts them into a container.

Picture 7.10. Extract the honey

STEP 6. Extract the honey
The freshly harvested honeycombs are put into a grinder to extract the honey.

Picture 7.11. Pack the honey

STEP 7. Pack the honey
The extracted honey is poured into jars.

Picture 7.12. Honey ready to be sold

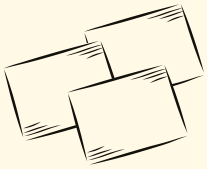
STEP 8. Sell the honey
The honey is now ready to be sold.

LESSON 23

What equipment does a beekeeper need?

23

Required materials



3 SHEETS OF A3 PAPER,
MANILA IF POSSIBLE

Preparation for the lesson

- Prepare a poster of a beekeeper's protective clothing based on Figure 7.3 using the three A3 sheets stuck together (as shown in the Figure).
- Cut out the six illustrations of beekeeper's tools (Figures 7.5–7.9) at the end of the chapter.

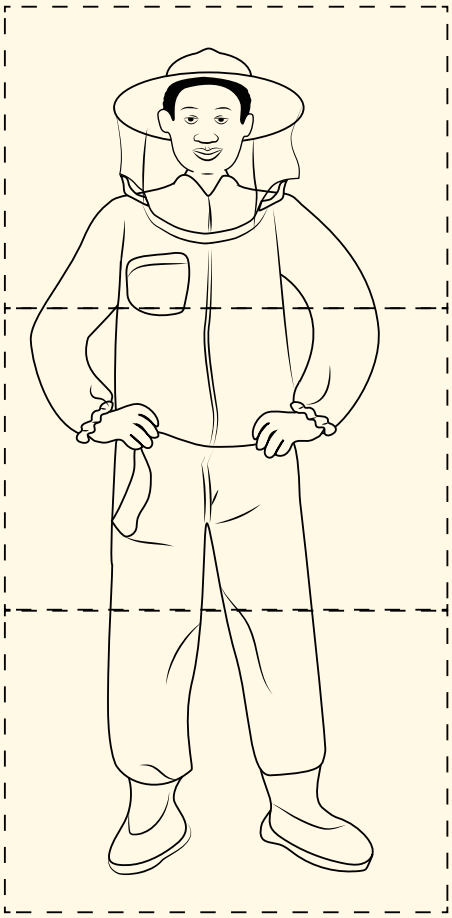


Figure 7.3. A beekeeper in protective clothing

1 Activity 1: Give a beekeeper the tools they need

indoor

This activity should take **40 minutes**.

1. Organize the class into five groups of equal size. Give to each group one illustration of a beekeeper's tool.
2. One person from each group will read aloud the description of their tool.
3. Place the poster of the beekeeper on the floor.
4. **Explain:** Beekeepers wear protective clothing that enables them to tend their bee colonies without being stung.
   - A beekeeping suit ("bee suit") is a set of overalls that covers the entire body except the head, neck, hands and feet. It is designed to protect beekeepers from bee attacks when they remove honey from hives or work near them.
   - Beekeepers also wear hats and veils to protect the head and neck. The veil can be zipped to the bee suit so no bees can get in.
5. Tell the pupils that beekeepers also use tools:
   - Smokers to help calm the bees.
   - Hive tools for separating the wooden boxes and bee brushes to gently remove bees from the honeycombs. In this way, beekeepers can collect honeycombs without destroying colonies or harming the bees.
6. Ask each group, one at a time, to place their illustration on the poster, around the beekeeper. As they place it, one pupil from the group should explain what the tool in the photo is used for.
7. Ask the pupils to copy the illustration of the beekeeper, the tools, and the description of each tool into their exercise books.

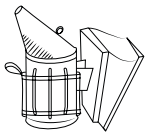
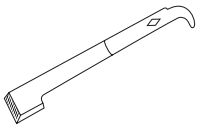
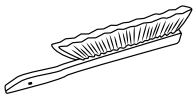
	**Smoker:** A bee smoker is a stainless steel device with bellows that puff smoke over the beehive to calm the bees. Various dry, natural materials such as pine needles, herbs and straw can be burnt inside the smoker to make smoke.
	**Hive tool:** Beekeepers use blunt metal tools called hive tools. One end of the chisel is a blade, which is mainly used to scrape propolis from inside the hive. The other end of the chisel is bent at a right angle. Beekeepers use this to separate hive boxes from each other.
	Gloves: Beekeeping gloves are made of leather or other tough, flexible material. They protect the beekeeper's hands from bee stings.
	**Bee brush:** Bee brushes are used to gently remove bees from surfaces. They have long, soft bristles that are gentle enough to remove live bees from delicate combs, frames, equipment and even beekeepers without harming the bees.
	Smoking materials: Dry pine needles, herbs, straw and other organic matter can be used to generate smoke in a bee smoker. The smoke calms the bees.

Table 7.1. Beekeepers' tools

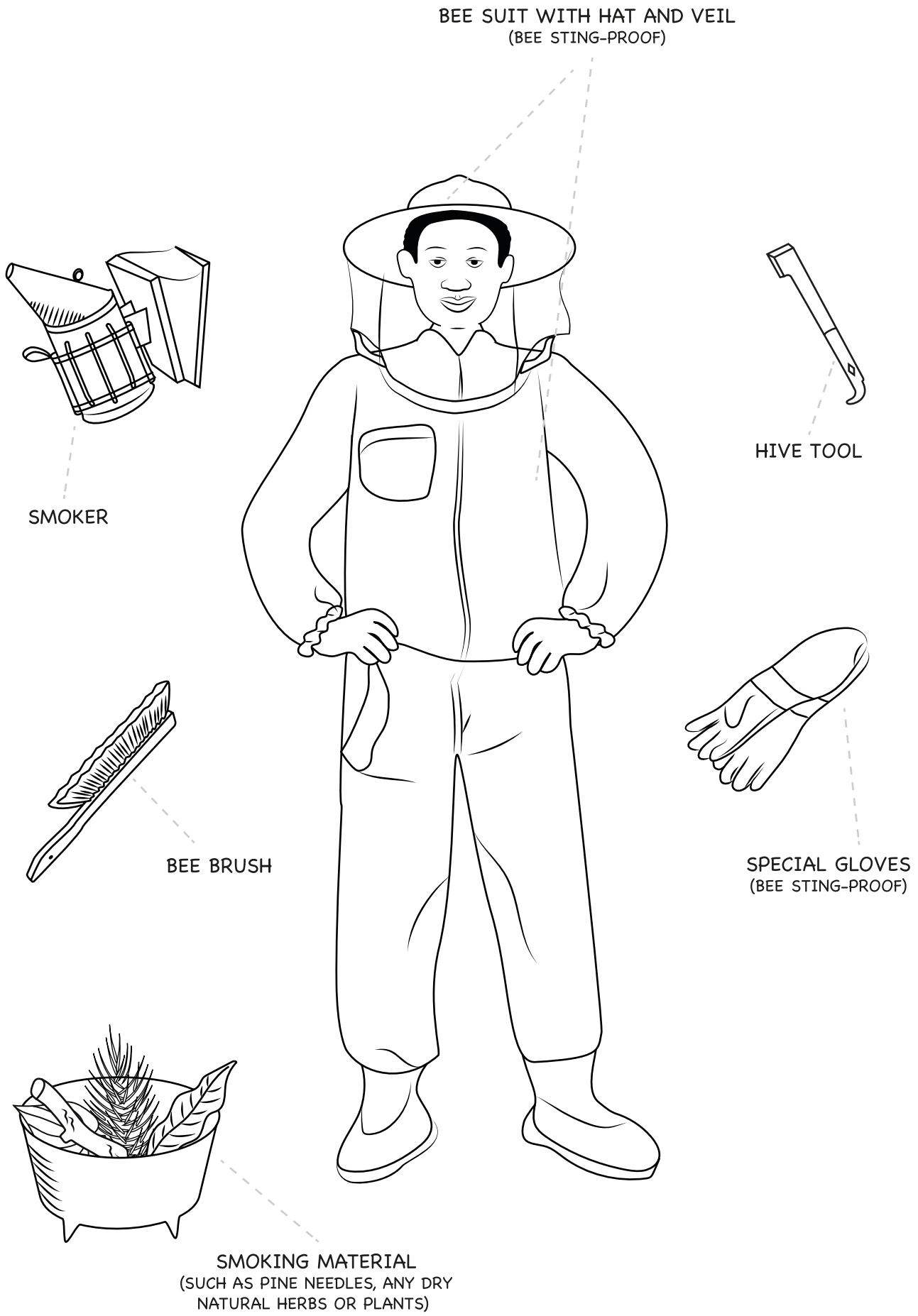


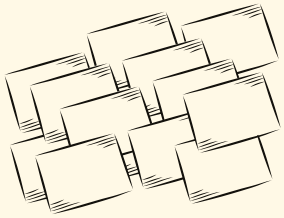
Figure 7.4. Full kit of a beekeeper

LESSON 24

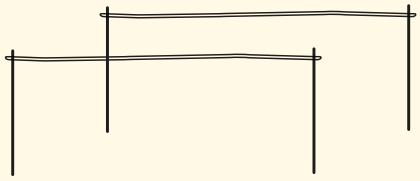
Discover a beekeeper's year

24

Required materials



30 MANILA CARDS



2 CLOTHESLINES

18 CLOTHES PEGS

Preparation for the lesson

- String up two clotheslines in the schoolyard.
- Prepare three sets of nine cards using the text below (points 1–9), writing on each card one of the nine actions or features in a year of beekeeping. There are three main periods: "build-up", "harvest", and "dearth". Write each of these three periods on the three remaining cards.

Build-up period

1. Flowering of melliferous plants (remind the pupils that melliferous plants are plants that produce substances – such as nectar – that honeybees collect and turn into honey).
2. Increase the number of boxes.
3. Collect swarms.

Harvest period

4. Harvest honey.
5. Spin honey in centrifuges.
6. Sieve the honey and fill honey jars.

Dearth period

7. Fewer flowering plants in the dry season.
8. Supplement bees' forage with sugar syrup.
9. Repair hives and equipment.

Tip: If possible, invite a professional beekeeper into the class to give a talk so that pupils can learn first-hand about the work of a beekeeper and its challenges.

1 Activity 1: Sort the stages of a year of beekeeping

outdoor

This activity should take **30 minutes**.

1. Take the pupils outside. They should bring their pupils' books and exercise books with them.
2. Organize the pupils into two groups of equal size. Give nine manila cards and nine clothes pegs to each group.
3. Explain to the pupils that each manila card shows a step or feature in a beekeeper's year.
4. Ask the groups to use the clothes pegs to attach the manila cards in the right order to one of the clotheslines (the two groups will use different lines). Give them a few minutes to carry out this task.
5. When they have finished, ask the groups to come together in the schoolyard. Using the third set of cards, lay out on the ground the working steps of a beekeeper's year in the correct order. Engage the pupils by asking for their help in determining the correct order.
6. Ask the groups to return to their clotheslines and compare their results with the one on the ground. The group that placed the highest number of cards in the correct sequence wins.
7. Add the three cards, "build-up", "harvest", and "dearth", to separate the three periods. Ask the pupils to copy the steps in the correct order, including the three periods to which they belong, into their exercise books.

2 Activity 2: Reflect on beekeeping

outdoor

This activity should take **10 minutes**.

1. If time allows, ask the pupils the following questions to recap what they have learned and to cement their learning. Allow the pupils to guess before giving the correct answers.
   - ► What happens to bees when there are fewer flowering plants?
   - » **Answer:** The bee colonies grow more slowly because there is less food. They don't accumulate as much honey.
   - ► What happens when a bee colony splits – when a swarm leaves the colony?
   - » **Answer:** There will be fewer bees in the colony to collect nectar and the colony will produce much less honey. If the swarm is caught, the beekeeper will have two bee colonies. If the swarm is not caught, all the bees in the swarm will be lost to the beekeeper.
   - ► Which do you think is the most difficult part of a beekeeper's year?

     Possible answers:

   - » The build-up period because bee swarms need to be collected.
   - » The harvest period – it is physically demanding to harvest the honey because the combs are heavy.
   - » Cleaning and repairs are hard work.
2. Conclude by **explaining:**

   to the pupils that, in addition to contributing to people's livelihoods, beekeeping increases agricultural production by providing pollination services. To ensure that their bees have enough food, beekeepers must look after melliferous plants in forests.

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6

Step 7

Step 8

Smoker.
A bee smoker is a stainless steel device with bellows that puff smoke over the beehive to calm the bees. Various dry, natural materials such as pine needles, herbs and straw can be burnt inside the smoker to make smoke.

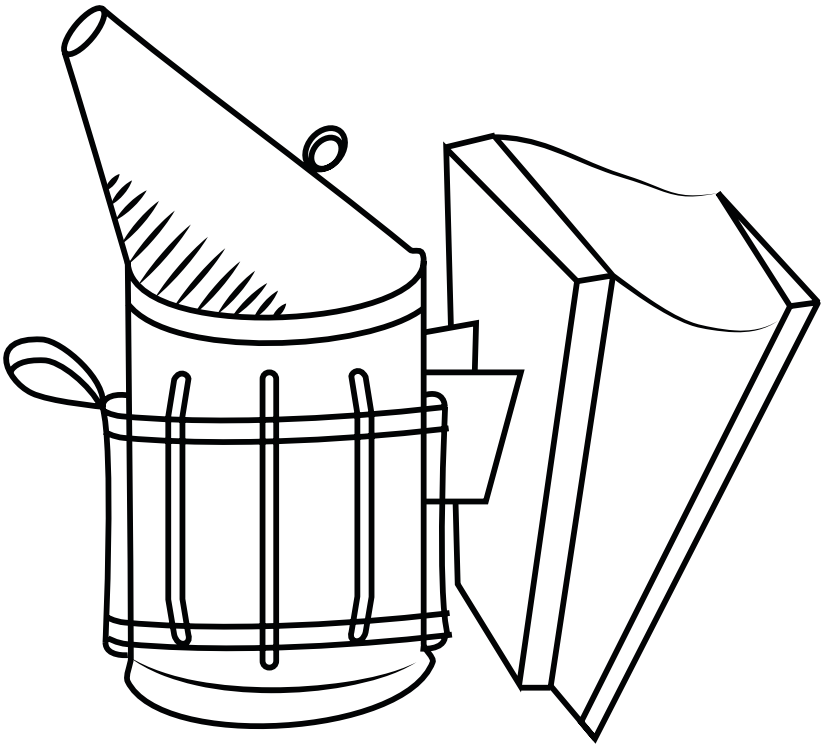


Figure 7.4. Smoker

Hive tool.
Beekeepers use a blunt metal tool called a hive tool. One end of the chisel is a blade, which is mainly used to scrape propolis from inside the hive. The other end of the chisel is bent at a right angle. Beekeepers use this to separate hive boxes from each other.

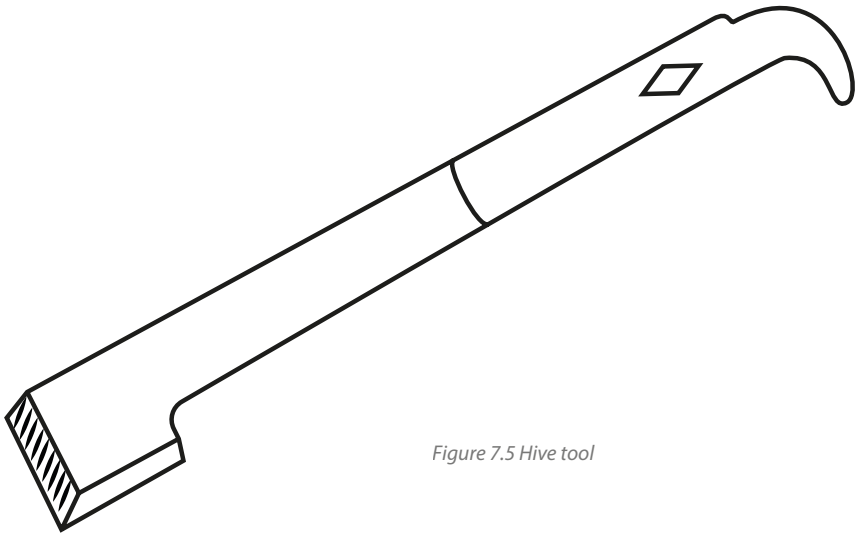


Figure 7.5 Hive tool

Gloves.
Beekeeping gloves are made of leather or other tough, flexible material. They protect the beekeeper's hands from bee stings.

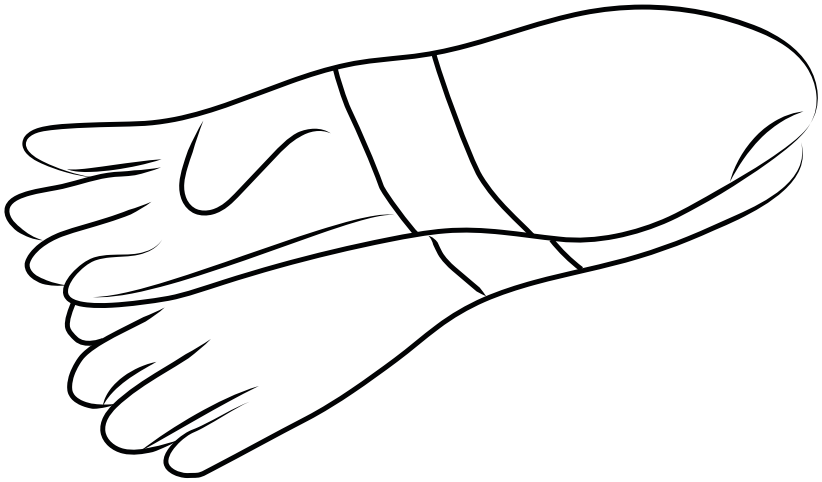


Figure 7.6. Beekeeping gloves

Bee brush.
Bee brushes are used to gently remove bees from surfaces. They have long, soft bristles that are gentle enough to remove live bees from delicate combs, frames, equipment and even beekeepers without harming the bees.

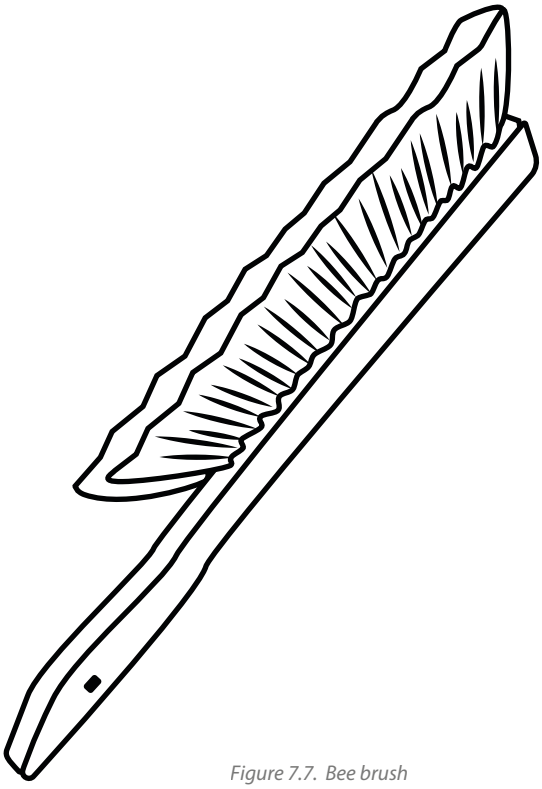


Figure 7.7. Bee brush

Smoking materials.
Dry pine needles, herbs, straw, dry cow dung and other organic matter can be used to generate smoke in a bee smoker. The smoke calms the bees.

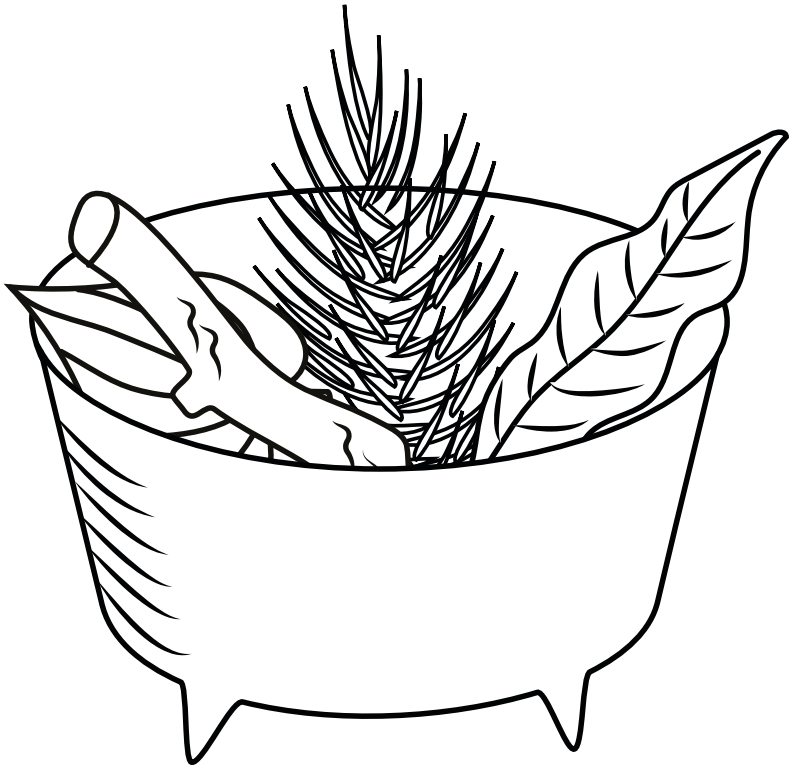


Figure 7.8. Organic matter for use in bee smokers

Preparation for the next lesson

Ask the pupils to think about some non-wood products from forests.

Notes

[1] **United Republic of Tanzania**. 2018. *Commercial Beekeeping Strategy in Tanzania*; 2018–2023. Tanzania Forest Services Agency. Ministry of Natural Resources and Tourism, p 44.

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CHAPTER 8

Forest products

Overview

In this chapter, the pupils will learn that forests produce many products in addition to wood, and they will learn to identify some of these. The pupils will learn the difference between wood and non-wood forest products through a guessing game. They will find examples of non-wood forest products and identify the plants and animals from which they are derived by creating and playing a matching game.

Objectives

By the end of the chapter, the pupils will be able to:

- define forest products;
- differentiate between wood and non-wood forest products; and
- identify five common non-wood forest products in the United Republic of Tanzania and the plants and animals from which they are derived.

Background information

What are forest products?

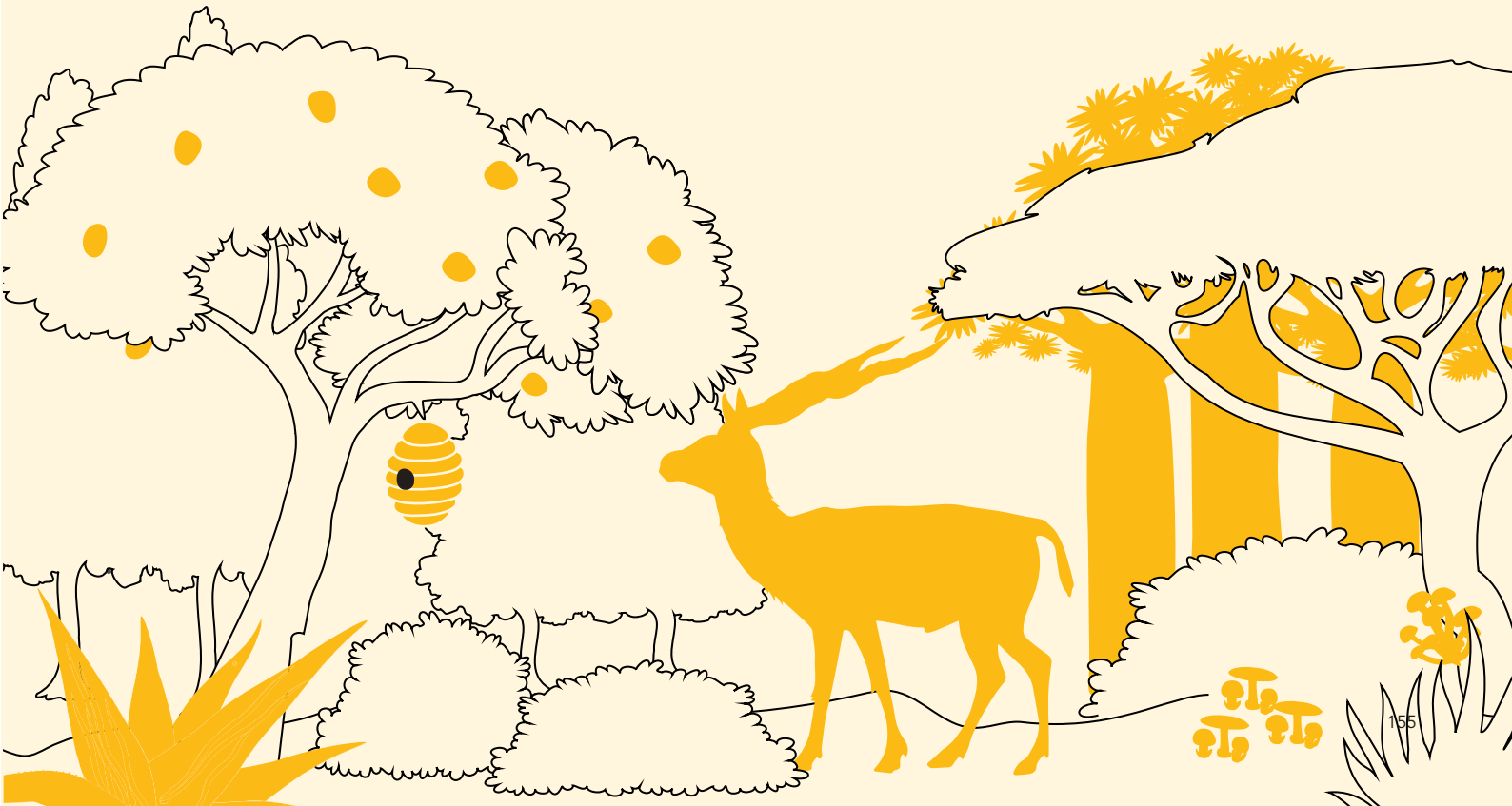
The main material that people get from forests is wood. Examples of wood products are timber (sawn boards), fence posts and rails, furniture, kitchen utensils, building materials, paper and woodfuel (fuelwood and charcoal). In monetary terms, timber is usually the most valuable wood product from forests, and large volumes are traded internationally. Woodfuel is also an important product: about 2.4 billion people, or one-third of the world's population, use it for cooking.[1] For many people, the energy from woodfuel is the only means they have for boiling (and hence sterilizing) water.

But forests are also a source of products other than wood. These are called non-wood forest products. Non-wood forest products include products of two different origins:

- **Plant** – such as foods (e.g. mushrooms, fruit, spices, herbs, nuts and seeds); fodder for livestock; raw materials for medicines; gums, resins and latexes; raw materials for colorants and dyes; raw materials for handicrafts, utensils and construction (e.g. cork); and ornamental plants.
- **Animal** – such as wild meat; honey and beeswax; hides; skins and trophies; living animals; and raw materials for medicines.

Non-wood forest products are important for many local communities, who may consume them themselves or sell them locally or internationally to earn income. In many forest communities, woodfuel and non-wood forest products such as food, medicinal plants and craft materials are especially important for enabling women to support their families by earning income.

On average, non-wood forest products provide around 20 percent of rural incomes in developing countries.[2] Globally, about 30 percent of all forests are managed primarily for the production of wood and non-wood products.[3]



What are the main products we get from forests?

Some products harvested in forests can be used as they are, and others provide raw materials for making other useful things. Many products that we use every day come from forests, although we might not realize it. Table 8.1 gives some examples.

Wood product	Raw material from forests
Paper	Wood fibre
Fabric	Wood fibre (wood-based fabrics such as viscose, modal and lyocell are used to make clothing, etc.)
Timber	Wood
Woodfuel (fuelwood and charcoal)	Wood
Non-wood forest product	**Raw material from forests**
Food	• Spices such as » cinnamon – from the cinnamon tree; and » pepper – peppercorns are the berries of the pepper plant, a kind of vine. • Tamarind – fruit from the tamarind tree is used to make juices and sauces. • Chewing-gum – some chewing-gum contains gum arabic, which is the hardened sap of acacias. • Wild meat – wildlife such as buffalo and wildebeest are hunted for their meat, which is rich in protein (a substance that is essential for a healthy diet). • Honey – from honeybees, which are also important for pollinating many forest (and agricultural) plants.
Tyres	Latex – the sap of rubber trees – is used to make car tyres and many other rubber products.
Fodder	The leaves and twigs of numerous trees are used as feed for livestock.
Stoppers for wine	A major use of cork, which is obtained from the bark of the cork oak, is to plug the necks of wine bottles.
Leather varnish	Tannin extracted from the leaves, bark and fruit of acacias is commonly applied to leather during the tanning process.
Candles	Beeswax, from honeybees, is used in candles and cosmetics and as a polish.
Others	Rattan, bamboo and lianas – from grasses and vines – are used to make furniture, crafts, paper and clothing.

Table 8.1. Wood and non-wood products harvested in forests

Why is it important to harvest forest products wisely?

Forests are renewable, which means that they will regrow after harvesting. They may cease to be renewable, however, if they are overharvested or damaged in other ways, such as by unplanned fires.

Forests need to be used wisely to protect their many values and to enable them to be harvested over and over again. This means not taking more from the forest than will grow back over time, protecting forests from threats and managing them sustainably.

Picture 8.1. Tamarindus

Picture 8.2. Timber

Picture 8.3. Tyres

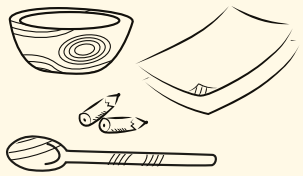
Picture 8.4. Cork stoppers

LESSON 25

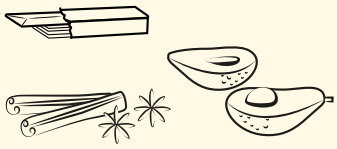
What products come from the forest?

25

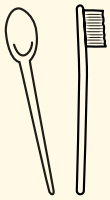
Required materials



WOOD PRODUCTS
(e.g. wooden spoon, wooden bowl, paper, wooden pencil)



NON-WOOD FOREST PRODUCTS
(e.g. cinnamon, fruit, chewing-gum)



1 OR 2 PRODUCTS THAT DO NOT COME FROM FORESTS
(e.g. an object made of plastic or metal such as a spoon, plastic comb or toothbrush)

Note: You may bring along more examples if you wish. It is important that the three product types are represented: wood product, non-wood forest product, and non-forest product.

1 Activity 1: Guess the wood and non-wood products

indoor

This activity should take **20 minutes**.

1. Organize the class into two equal-sized groups.
2. Explain to the pupils that they will play a guessing game in which the two groups compete. One by one, you will hold up objects the pupils are likely to know.
   - Some of these objects are made of wood.
   - Some are made with raw materials that come from forests but are not wood.
   - Some do not come from forests at all.
3. The pupils must guess whether the object you are holding up is a wood product, a non-wood product from a forest, or an object with no relation to forests.

4. Show an object to both groups. Tell the pupils to:
   - stand if they think that it is a wood product;
   - raise their hands if they think that it comes from a forest but is not wood; and
   - touch their noses if they think that it does not come from a forest.
5. Count the number of correct answers in each group and write the score on the board. Then tell the pupils the correct answer.
6. Repeat instructions 4 and 5 for each item.
7. The group with the highest score wins the game.

2 Activity 2: Reflect and brainstorm

indoor

This activity should take **20 minutes**.

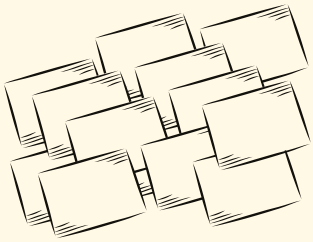
1. Ask the pupils to name products that come from forests (some possible answers: wood products such as fence posts, wooden floors and furniture, and paper).
2. Remind the pupils about the non-wood products in the previous activity and write the names on the board.
3. Ask the pupils to name any other products they can think of that come from forests but are not made of wood. Examples are:
   - food such as mushrooms from fungi and fruit, spices, herbs, nuts and seeds from plants;
   - food from animals, such as wild meat and honey; and
   - non-food products such as latex, cork, beeswax and rattan.
4. Write on the board the forest products named by the pupils, creating as long a list as possible.
5. Encourage the pupils to think about the products by asking:
   - What is the product?
   - Where does it come from? Is it a plant, an animal or a fungus? Can anyone name the species?
6. Allow a few pupils to volunteer answers. Correct and complete the answers, if necessary.

LESSON 26

Create a forest product matching game

26

Required materials



MANILA CARDS
1 per pupil, when cut in half

1 PAIR OF SCISSORS

Preparation for the lesson

- Cut each manila card in half to make two smaller cards. There should be one (half) card for every pupil.
- Copy the list in Table 8.1 onto the board.

Note: The list in Figure 8.1 is mismatched on purpose, and the pupils will later match the examples with the correct sources. The answers are in Lesson 26, Activity 2, but do not reveal these to the pupils until they have completed Activity 2.

GROUPS 1–5

LIST A – EXAMPLES

- Paper
- Wooden cooking spoon
- Energy-boosting medicinal remedy
- Fuelwood
- Pepper

GROUPS 1–5

LIST A – SOURCES

- Tree: various species
- Fruit: pepper plant
- Tree: various species
- Leaves: moringa tree
- Tree: softwood species

GROUPS 6–10

LIST B – EXAMPLES

- Cinnamon
- Balloon
- Name of a typical meat dish, such as mshikaki
- Table
- Wooden house

GROUPS 6–10

LIST B – SOURCES

- Animal: wildebeest
- Bark: cinnamon tree
- Tree: various species
- Tree: hardwood species
- Latex: rubber tree

Figure 8.1. Non-wood forest products, and their sources

Note: The number of items in the list should correspond to half the pupils in any one group and may need to be reduced or increased. If the class has 100 pupils and ten groups, each group will consist of ten pupils. This means that the lists should have five items each.

1 Activity 1: Create a matching game

indoor

This activity should take **20 minutes**.

1. Explain to the pupils that they will create cards for a matching game by drawing products that come from forests. They will later use the cards when they play the game.
2. Organize the pupils into ten groups of equal size. Assign each group a number from 1 to 10.
3. Give enough manila cards (full cards cut in half) to each group so that each pupil has one card.
4. Ask groups 1–5 to refer to List A on the board and groups 6–10 to refer to List B.
5. In each group:
   - half the pupils will each draw (on their cards) one of the products on their list ("List A – Examples", or "List B – Examples"); and
   - the other half of the pupils will each write the source of one of the products on their manila cards.
6. The pupils in each subgroup will need to decide which pupil draws which product or writes the name of which source.

Important: All the products and sources of products mentioned in the list must be drawn or written on the cards.

7. At the end of the activity, each group should have a full set of cards with all the examples and sources on either List A or List B.

2 Activity 2: Match forest products with their sources

indoor

This activity should take **20 minutes**.

1. Explain to the pupils that each group has made a matching game using examples of products made from wood and other forest products and the plants and animals from which they come.
2. Ask the pupils to work together in their groups to match the products with their sources.
3. Walk around and, in a low voice, help each group match the cards correctly. Answers are available on pages 162 and 163.

Important: Each group should talk among themselves in low voices and should not tell or show the other groups their answers. The idea is for the pupils in each group to interact and brainstorm. In the next activity, the groups will switch cards and play the game using another group's cards – but don't tell them that yet!

4. At the end of the activity, collect the cards, making sure that each set is kept intact and that the sets of groups 1–5 are kept separate from the sets of groups 6–10.

LESSON 27

Play a forest product matching game

27

1 Activity 1: Match forest products with their sources

indoor

This activity should take **25 minutes**.

1. Organize the class into the same groups as in the previous lesson.
2. Explain that they are now going to test their skills in a matching game. To make things more exciting, they will play using sets made by another group.
3. Distribute the cards. Give the cards of groups 1–5 to groups 6–10 and the cards of groups 6–10 to groups 1–5.
4. Explain the rules of the game:
   - Shuffle the cards.
   - Lay them out face up.
   - Think about which product card belongs to which source card.
   - Place the product card next to the appropriate source card.

2 Activity 2: Reflect and discuss

indoor

This activity should take **15 minutes**.

1. Ask one group from groups 1–5 to present the results of their game.
2. If there are any uncertainties, correct or add the missing information. The correct answers are given below.
3. Ask one group from groups 6–10 to present their results.

Groups 1–5
List A – Examples and sources

Firewood →	Tree: various species
Pepper →	Fruit: pepper plant
Paper →	Tree: various species
An energy-boosting medicinal remedy →	Leaves: moringa tree
Wooden cooking spoon →	Tree: various species

Groups 6–10
List B – Examples and sources

Name of a typical meat dish (e.g. *mshikaki*) →	Animal: wildebeest
Cinnamon →	Tree bark: cinnamon tree
Table →	Tree: various species
Wooden house →	Tree: various species
Balloon →	Latex: rubber tree

4. Finally, ask the pupils whether they already knew that all the forest products they learned about in this chapter came from forests. Did any surprise them?
5. Ask the pupils to copy the correct answers on the board into their exercise books.
6. **Explain:** Gathering products from forests is often a main source of income for women, especially in remote areas.

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Notes

[1] **FAO**. 2017. *The charcoal transition: Greening the charcoal value chain to mitigate climate change and improve local livelihoods.* Rome. www.fao.org/3/i6934e/i6934e.pdf

[2] **FAO & UNEP**. 2020. *The State of the World's Forests 2020–Forests, biodiversity and people.* Rome. https://doi.org/10.4060/ca8642en

[3] **FAO**. 2020. *Global Forest Resources Assessment 2020– Key findings.* Rome. https://doi.org/10.4060/ca8753en

CHAPTER 9

Our forests in the United Republic of Tanzania

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Overview

In this chapter, the pupils will learn about the types of forests in the United Republic of Tanzania and their diversity, as well as about the threats they face. They will learn about the country's forest types through a quiz and a drawing activity. They will also learn about the diversity of tree and shrub species by solving a puzzle.

Objectives

By the end of the chapter, the pupils will be able to:

- identify the different types of forests in the United Republic of Tanzania;
- explain the difference between natural and planted forests;
- identify various tree species commonly found in natural and planted forests in the United Republic of Tanzania; and
- explain the main threats to forests in the United Republic of Tanzania.

Background information

How much forest is there in the United Republic of Tanzania?

The United Republic of Tanzania is known for its biodiversity. It is home to more than 7 000 plant species, which is more than one-third of all plant species in Africa, and many of them grow in forests. The most common tree species in the native forests of the United Republic of Tanzania are the horn-pod tree (*mtogo*), the large-fruited bushwillow (*mlama*), the bean-pod tree (*myombo*) and the velvet bushwillow (*msana*) (see Chapter 2).

Forests in the United Republic of Tanzania are estimated to cover about 48 million ha (hectares), which is more than half of the country's mainland.[1] Forests are present in all parts of the country, from the Southern Highlands to the lake area.

There are many types of forests in the United Republic of Tanzania, depending on their location and other factors. Forests provide Tanzanians with many products and services that support livelihoods.

More than 60 percent of the country's forests are designated as protected areas to conserve them and their wildlife.[2]

What types of forests grow in the United Republic of Tanzania?

The following main types of forest vegetation types occur in the United Republic of Tanzania:

- **Montane forests.** These occur at about 2 500 metres m (metres) above sea level and higher, such as on Mount Kilimanjaro, Mount Meru and the slopes of the Ngorongoro Crater. They are rich in plant and animal species.
- **Lowland closed-canopy forests.** These are forests in which the trees grow closely enough that their top branches and leaves (their "crowns") nearly touch, forming a canopy that allows little light to penetrate and reach the forest floor. The vegetation on the forest floor is sparse. Lowland closed-canopy forests are found in the United Republic of Tanzania on the lower slopes of the ancient mountains of the Eastern Arc, along the Albertine Rift, around Lake Tanganyika in the west, and on the younger volcanic mountains in the north and central parts of the country.
- **Mangroves.** These are a type of coastal forest that grows in salty water. The roots of mangrove trees grow out of the mud to support their trunks and crowns. These stilt-like roots enable the trees to survive regular flooding with salty water as the tide comes in and goes out. The mangroves of the United Republic of Tanzania grow along the Indian Ocean coastline, on both the mainland – such as the Rufiji estuary – and the islands.
- **Deciduous miombo woodlands.** These are dominated by trees (called deciduous trees) that lose their foliage at the end of the growing season. The ground is covered only sparsely by grasses and shrubs. Deciduous miombo woodlands are found in the western, central and southern parts of the United Republic of Tanzania.
- **Plantations.** These are forests planted by people, mainly for commercial wood production. They mostly comprise only one or two tree species, which grow in stands in which the trees are all the same age. Usually, trees in plantations are arranged in rows to maximize the site's growing space and to make harvesting easier.[3] In the United Republic of Tanzania, the main trees grown in plantations are *Pinus* and *Eucalyptus* species, which have been introduced from other continents. Some native trees, such as *Khaya* species (*mkangazi*) and *Dalbergia* species (*mkongo*), are also planted.

Picture 9.1. Montane forest

Picture 9.2. Lowland closed-canopy forest

Picture 9.3. Mangrove

Picture 9.4. Deciduous myombo woodland

Picture 9.5. Plantation

What are the main threats to forests in the United Republic of Tanzania?

The United Republic of Tanzania lost 420 000 ha of forest per year between 2010 and 2020 or about 9 percent of the country's total forest area.[4] The main causes of forest loss are:

- agricultural expansion and unsustainable slash-and-burn practices;
- excessive firewood and charcoal production and Illegal logging;
- the expansion of settlements; and
- mining.

The key to maintaining forests over time is to manage them sustainably. A sustainably managed forest ensures that what is taken from a forest grows back before the next harvest. Sustainable forestry also maintains the quality of forest habitat for animals and plants. For example, illegal logging and unsustainable slash-and-burn practices are incompatible with sustainable forestry.

The United Republic of Tanzania has put in place laws, regulations and programmes designed to encourage sustainable forestry, including the development of alternatives to fuelwood and charcoal in households, and building awareness of the importance of forests. Forest owners and managers are required to implement proper land-use and forest management plans.

Picture 9.6. Hills behind the Hondo Hondo Udzungwa Mountains tented camp

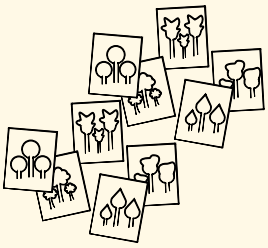
LESSON 28

What do you know about Tanzanian forests?

28

Required materials

MAP OF THE UNITED REPUBLIC OF TANZANIA



2 PICTURES OF EACH FOREST TYPE
(one for each group)

1 PAIR OF SCISSORS
TO CUT OUT THE PICTURES

Preparation for the lesson

Cut out the photos of the different forest types shown on pages 177–195. If the pupils have their pupils' books, they will find the picture there, and there is no need to cut in the pictures out this book.

1 Activity 1: Test what you know about forests

indoor outdoor

This activity should take **10 minutes**.

1. Explain to the pupils that the lesson will start with a forest quiz.
2. Explain the rules to the pupils:
   - » You will listen as I read out a question and three possible answers.
   - » You will have a short time to think about the answer.
3. Now, read each question and the possible answers. Wait a few seconds, then read the question and possible answers again.

4. Ask a few pupils to volunteer answers and then give the correct answer.
5. Repeat with the other questions.

   Questions (the correct answers are in bold):

   - How much of the country's land area is covered by forest?
     - a. The entire land area is covered by forest.
     - b. **More than half the land area is covered by forest.**
     - c. Only a very small part of the land area is covered by forest.

   - Where do forests grow in the United Republic of Tanzania?
     - a. Forests grow only in the mountains.
     - b. Forests grow only in coastal areas.
     - c. **Forests grow in all parts of the United Republic of Tanzania, from the Southern Highlands to the lake area.**

   - Do all forests in the United Republic of Tanzania look the same?
     - a. Yes, all forests in the United Republic of Tanzania look about the same.
     - b. **No. The forests vary depending on where they are and on the trees, plants and animals that live there.**

6. On the map, show the pupils where the Southern Highlands and the lake area are in the United Republic of Tanzania, and explain that forests are also found on the coast and in other places all over the country.

2 Activity 2: Recognize and describe different forest types

This activity should take **30 minutes**.

1. Tell the pupils that they will now learn about the different types of forests in the United Republic of Tanzania.
2. Organize the class into ten equal-sized groups.
3. Give each group one of the forest photos that you cut out from pages 177–195. Place the photos face down (so the pupils will listen without distraction).
4. Explain the task to the pupils as follows:
   - When I tell you, you will turn over your photo and look at it closely.
   - Each group will discuss among themselves and describe what they see:
     - Are there plenty of grasses and shrubs?
     - Are the roots underground or in water?

- Are the tree canopies close together or far apart?
- Is there a lot of light coming into the forest?
- Where does the forest grow (coast, mountain or plain)?
- Are the trees all the same species and height, or are there many types and sizes of tree?
- Are the trees evenly spaced?

5. Tell the pupils to commence the task.
6. After 10 minutes, ask each group to present their results to the class.
7. Hold up one of the large photos of the forest types and ask the pupils in the group with the same photo to describe what they see:
    - What did you notice?
    - How would you describe the forest?
    - Where do you think this forest grows (e.g. coast, mountain or plain)?

8. For each of the photos, read the following text related to that type of forest:
    - **Montane forests** occur high up on the slopes of mountains, at 2 500 m above sea level or higher. They are rich in plant and animal species. Montane forests are found on the upper slopes of Mount Kilimanjaro, Mount Meru and the Ngorongoro Crater, as well as on other mountains.
    - **Lowland closed-canopy forests** are forests in which the trees grow closely enough that their top branches and leaves (their "crowns") nearly touch, forming a canopy that allows little light through to the forest floor. With such limited sunlight, few plants grow under the big trees. Lowland closed-canopy forests are found in the United Republic of Tanzania in the west on the lower slopes of the ancient mountains in the Eastern Arc, along the Albertine Rift, and around Lake Tanganyika and on the younger volcanic mountains in the north and central parts of the country.
    - **Mangroves** grow along coastlines. The roots of mangrove trees grow out of the mud to support their tree trunks and branches. These stilt-like roots enable the trees to survive regular flooding with salty water as the tide comes in and goes out. The mangrove forests of the United Republic of Tanzania grow along the Indian Ocean coastline, such as in Tanga, Dar es Salaam and Pwani.
    - **Deciduous miombo woodlands** are important habitats for many wild animals, especially large mammals such as antelopes, elephant, giraffe, rhino and lion. The trees are widely spaced, and the ground is covered only sparsely by grasses and shrubs. Deciduous miombo woodlands occur in the west, centre and south of the country.
    - **Plantations** are forests planted by people, mainly to grow wood. They are generally composed of only one or two tree species, which grow in groups of the same age. Usually they are planted in rows. In the United Republic of Tanzania, the main trees grown in plantations are pines and eucalypts, which have been introduced from other continents. Some native trees, such as mkangazi and mkongo species, are also planted.

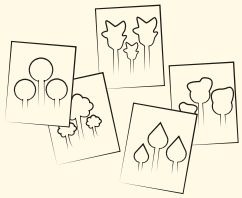
LESSON 29

Discover the tree species in Tanzanian forests

29

Required materials

1 PAIR OF SCISSORS
TO CUT OUT THE PICTURES



PICTURES OF EACH TREE SPECIES WITH LEAVES, FLOWERS AND FRUITS
(one for each group)

Preparation for the lesson

- Before the lesson, cut out the five photo collages on pages 197 to 205. Cut each collage into three or four pieces. Each collage is composed of four photos, one representing the whole tree, one the leaves, one the flowers and one the fruit. It will be more challenging for the pupils if you cut across the photos to make a puzzle.
- Place the puzzles in five piles in the schoolyard. There should be one puzzle pile for each tree species. Make sure there is enough space around each pile to enable 20–25 pupils to gather there. Use a rock to weigh the papers down and stop them blowing away.

1 Activity 1: Make a tree puzzle

outdoor

This activity should take **15 minutes**.

1. Organize the pupils into five equal-sized groups.
2. Explain the task to the pupils as follows:
   a. There are five piles of puzzle pieces. The pieces can be put together to make a picture of a single tree species, showing the whole tree as well as its leaves, flowers and fruit. You studied some of these tree species in Chapter 2.
   b. Your task is to:
   » put the puzzle pieces together correctly; and

» memorize the special features of your tree so that you can describe it to your classmates:
  - What shape does the tree have?
  - What does the bark look like?
  - What do the leaves look like?
  - What do the flowers look like?
  - What does the fruit look like?
  - What is the name of the tree?
  - What is the tree used for?

c. You have 10 minutes to do this.

3. Clap your hands to start the exercise and then again after 10 minutes to end it.

2 Activity 2: Discuss and reflect

indoor outdoor This activity should take **25 minutes**.

1. Ask the pupils to form a circle around one of the groups and their completed tree puzzle. The pupils should be able to hear you, as well as see the puzzle.
2. Ask the pupils who completed the puzzle to describe the tree, prompting them with the following questions:
   - What shape does the tree have?
   - What does the bark look like?
   - What do the leaves look like?
   - What do the flowers and fruit look like?
   - What is the name of the tree?
3. Then, repeat steps 1 and 2 around the next tree puzzle. Continue in this way for the remaining groups.

! **Note:** As homework, ask the pupils to sketch, on manila cards, the whole tree, leaves, bark, flowers and fruit (one feature per card) and write the name of the tree underneath. You can then put these "tree identification" cards on the walls of the classroom.

Preparation for the next lesson

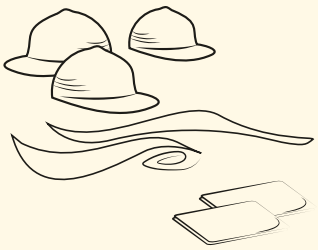
Ask about 30 pupils to bring a cap, scarf, handkerchief or plastic bag to the next lesson. As another option, bring these items in yourself.

LESSON 30

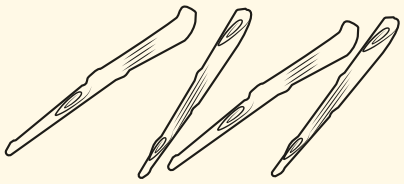
Play a wood resource catching game

30

Required materials



CAPS, SCARVES, HANDKERCHIEFS AND PLASTIC BAGS
(brought by the pupils)



4 STICKS TO MARK OUT THE PLAYING FIELD

Preparation for the lesson

Using four sticks, mark out a playing field in the schoolyard in a square approximately 25 m x 25 m.

1 Activity 1: Catch wood resources

outdoor

This activity should take **25 minutes**.

1. Tell the 30 pupils who brought in caps, scarves, handkerchiefs or plastic bags that they are now "pieces of wood" in a game and ask another pupil to act as the "human". The rest of the pupils will be observers and should line the four boundaries of the playing field.
2. Explain the rules of the game:
   - Each of the 30 players will put on their cap or tie their scarf, handkerchief or plastic bag around their wrist and walk onto the playing field. These players represent pieces of wood from the forest trees of the United Republic of Tanzania.
   - The pupil representing the human does not wear a cap or have a scarf, handkerchief or plastic bag on their wrist. The human's task is to catch as many of the other players (representing pieces

of wood) as possible by touching them or calling their names when they are close to them. With each piece of wood caught, the human increases their standard of living.

- When they are caught, the players turn into humans and become catchers. To show this, they remove their caps or other items and hand them to the teacher.
- You will send one observer onto the playing field every 2 minutes or so, giving them a cap (or scarf, handkerchief or plastic bag) from one of the previous players who has already been caught. Once inside, this observer will become a player (representing a piece of wood). The new players represent the regrowth of wood resources.

3. Keep the game going until all the observers have become players and all the players have been caught and become humans.

2 Activity 2: Discuss and reflect

outdoor

This activity should take **15 minutes**.

1. Ask the pupils to sit on the ground in a circle so that they can all see each other.
2. Ask two to three of the pupils who were observers what they noticed about the game. They will have noticed different things.
3. The main idea of the game is to show how wood is used up by humans. If the pupils' answers do not lead to this idea, direct them towards it by asking what happened to the pieces of wood.
4. **Explain:** The more that people used wood, the less wood was available. Although wood always grew again (as the new "pieces" came onto the playing field), it was not enough. At the end of the game, there were only "humans" and no more "pieces of wood".
5. Then relate the game to the situation in the United Republic of Tanzania. **Explain:**
   - We could face a similar situation in the United Republic of Tanzania. Although more than half the mainland is still covered by forests, we have to be careful. More forest is being cleared than is being replanted and can grow again.
   - Forests are cleared to make new farms and grazing lands, expand cities and make roads.
   - Also, forests are being harmed by wildfires, illegal logging and unsustainable slash-and-burn practices.
   - It is possible to use forests, as long as we do so sustainably. This means taking care of the forests and not harvesting more wood and other products than will regrow before the next harvest. Illegal logging and unsustainable slash-and-burn practices are incompatible with sustainably managed forests.
   - The best way to conserve our forests is to practise sustainable forestry – in that way, we can keep our forests and use them, too!
6. Read the last sentence again to the class and ask them to write it in their exercise books.

Montane forest

Montane forest

Lowland closed-canopy forest

Lowland closed-canopy forest

Mangrove

Mangrove

Deciduous miombo woodland

Deciduous miombo woodland

Plantation

Plantation

Large-fruited bushwillow (*mlama*)

Horn-pod tree/wild rubber (*mtogo*)

Bean-pod tree (miombo)

Velvet bushwillow (*msana*)

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Eucalypt

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Notes

[1] **FAO**. 2020. *Global Forest Resources Assessment 2020–Main report*. Rome. https://doi.org/10.4060/ca9825en

[2] **FAO**. 2020. *United Republic of Tanzania*. Country report prepared for the Global Forest Resources Assessment 2020. Rome. 54 pp. www.fao.org/3/cb0085en/cb0085en.pdf

[3] **Gumbo, D.J., Dumas-Johansen, M., Muir, G., Boerstler, F., Xia, Z.** 2018. *Sustainable management of Miombo woodlands – Food security, nutrition and wood energy*. Rome, FAO.

[4] **FAO.** 2020b. *United Republic of Tanzania*. Country report prepared for the Global Forest Resources Assessment 2020. Rome. 54 pp. www.fao.org/3/cb0085en/cb0085en.pdf

Glossary

Afforestation. The establishment of a forest through the planting or deliberate seeding of land that, until then, was not forested.

Antioxidants. Vitamins and other nutrients that help reduce damage to cells in human bodies; they may help reduce serious health problems such as cancer and heart disease. Antioxidants are found in healthy foods, particularly brightly coloured vegetables and fruits.

Apiculture. Also known as beekeeping, or the practice of managing honeybees, commonly in artificial hives to obtain bee products such as honey, beeswax, propolis, pollen, bee venom, royal jelly and queen bees. Apiculture is also used to ensure crop pollination and increase biodiversity. It can support a healthy environment if practised sustainably.

Bee smoker. A stainless-steel device with bellows that distributes smoke over the beehive to make bees less aggressive. Various dry natural fuels, such as pine needles, herbs and straw, can be used to generate the smoke.

Biodiversity. The variety of living organisms on the Earth.

Brood comb. Rows of hexagonal wax cells, formed by bees in their hives where the queen bee lays her eggs. The colony grows when the size of the brood comb increases. When a queen has insufficient brood comb to lay eggs, the colony may be more prone to swarming.

Colony. A group of organisms of the same species or group living or growing together. A honeybee colony comprises drone bees, worker bees and a queen bee, each with its own functions in the colony.

Dearth period. A part of the year in which there are few flowers and no honey flow.

Deciduous tree. A tree, the leaves of which fall off or shed seasonally or at a certain stage of development in their life cycle.

Erosion. The detachment, transportation and deposition of stones, gravel, sand and other soil materials caused by water, wind and ice. It has increased greatly in recent decades due to interventions by people. Trees and other plants can reduce erosion.

Exoskeleton. An external skeleton or shell that protects and supports an animal's body.

Fern. A plant with large leaves and no flowers that grows in wet areas (such as the understorey of moist forests). There are many species of fern.[1]

Habitat. Conditions well suited to a particular animal or plant, providing it with food, reproductive capacity and shelter.

Herbicide. A chemical used to kill unwanted plants. Herbicides are not usually toxic to people but may harm non-pest plants and insects, including honeybees and other pollinators.

Hive. A natural or artificial structure that houses a honeybee colony. It comprises various areas with different functions to support the colony, especially brood comb and honeycomb.

Honeycomb. Rows of hexagonal wax cells formed by bees in their hives and used to store honey and sometimes pollen. When the honey is ripe, the cells are sealed with wax lids.

Humus. An organic component of soil formed by the decomposition of leaves, animals and other organic materials.

Illegal logging. The harvesting, processing, transporting, buying or selling of timber in contravention of national and international laws.

Inorganic material. Material derived from non-living sources such as rocks and minerals.

Larvae. Infant forms of some insects. A larva or young insect hatched from an egg differs completely in form from the adult.

Latex. A milky white fluid obtained by cutting a rubber tree to make it bleed.

Lichen. A slow-growing, plant-like organism that typically forms a low crusty, leaflike or branching growth on rocks, walls and trees.[2]

Melliferous plant. A plant that produces substances that can be collected by honeybees and turned into honey.

Moss. A small green or yellow plant with no flowers that grows on (and spreads over) wet surfaces such as rocks and trees.[3]

Natural forest. A forest composed of local tree species that have regenerated naturally.

Naturally regenerated forests. Forests that regenerate from trees that have developed from seeds fallen from trees in the forest.

Nectar. A sugary fluid secreted by flowers to encourage pollination by insects and other animals. It is collected by bees to make honey.

Non-wood forest products. All goods of biological origin other than wood, derived from trees.

Organic matter. Matter derived from the remains of plants and animals and their waste products in the environment.

Pesticide. A substance used to kill or repel certain animal species considered pests, such as various insects. Pesticides may also be toxic to people and non-pest species, such as honeybees and other pollinators.

Phloem. The living tissue in tree stems containing small tubes ("vessels") that transport water, sugar and other nutrients to the various plant parts.

Plantation forest. Forest planted by people, mainly for commercial wood production.

Planted forest. Any forest established by people by planting or deliberate seeding. Planted forests can grow wood efficiently and can also restore degraded lands. They may be composed of local or exotic (non-local) tree species.[4]

Pollen. A powdery substance consisting of pollen grains from male seed plants used by plants for cross-pollination. Bees collect pollen grains from flowers on their hind leg hairs and other parts of their bodies and distribute these to other flowers, thus pollinating them. Bees also store pollen in their hives. The stored pollen is an important source of food for bees because it is rich in protein and contains essential amino-acids and fats. This is why the pollen mixture is also called "bee bread".

Pollination. The transfer of pollen from the male part of a flower to the female part of a flower. The flowers may be on the same plant or on different plants of the same species.

Pollinator. An animal that transfers pollen from the male part of a flower to the female part of a flower. Pollinators include honeybees, solitary bees, bumblebees, wasps, ants, flies, mosquitoes, butterflies, moths, beetles, bats and birds.

Production forest. Forests that produce commercial forest products, such as wood.

Propolis. A sticky substance that honeybees make by mixing their saliva with tree sap and other liquids that they collect from plants. Honeybees use propolis to seal unwanted open spaces in beehives. It is mostly dark brown, depending on the botanical source. Propolis is sticky at over 20 °C and hard and brittle at lower temperatures. It is also known as bee glue, and it has antibacterial, antiviral and antifungal properties.

Reforestation. The re-establishment of a forest through planting or deliberate seeding.

Resin. A sticky fluid produced by some plants when they are damaged to help close the wound.

Royal jelly. A honeybee secretion used to provide nutrition for bee larvae and adult queen bees. Nurse bees secrete royal jelly from glands. It is fed to worker bees and male larvae for three days and to the queen bee larvae until the queen bee emerges. This and the intensive care provided by nurse bees are the reasons why queen bees differ from other female bees.

Sapling. A young tree (but older and larger than a seedling).

Seedling. A very young plant that has grown from seed.

Silviculture. The practice of controlling the establishment, growth, composition, health and quality of a forest to achieve certain objectives. Silviculture encompasses a variety of practices, such as choosing which species to plant or favour, planting seedlings, removing some trees as the forest grows to make space for others, pruning (sometimes done to improve wood quality when the trees are later harvested), and weed control.

Slash-and-burn practices. Cutting down and burning plants and trees to clear land for cultivation. In sustainable slash-and-burn, the land is cultivated for a few years and then allowed to grow back into forest for many years (a period called "fallow"). When the fallow period is too short, however, slash-and-burn can be unsustainable and may lead to permanent deforestation.

Soil pores. Cavities that transport liquids or gases and thus also nutrients. They are often filled with water or air.

Supers. The wooden boxes used as hives in beekeeping. It is common to stack supers, one on top of the other.

Swarm or swarming. A honeybee colony's natural means of reproduction. In the process of swarming, a single colony splits into two or more distinct colonies. When they find a new home, they settle and begin building a new colony. The urge to swarm depends on the available space in the hive and the supply of nectar and pollen.

Tree nurseries. Places where trees are grown from seeds or cuttings and grown to a size suitable for planting in the field.

Vegetable gum. Solid material usually produced by damaged plants to help close a wound or sometimes obtained from plant roots. Vegetable gums, when placed in water, either dissolve in or absorb water and swell up.

Vegetative propagation. A method of growing new trees without seeds – it might involve taking a "cutting" (a branch from a living tree), which will sprout and eventually grow into another tree.

Wildlife protected areas. Areas managed specifically to protect particular wildlife species or habitats.

Xylem. Thick, hard and mostly dead tissue in the stem that forms hollow pipes (vessels), through which water and nutrients are transported from the roots of the tree to the crown.

Notes

[1] **Oxford Learner's Dictionaries**. undated. Definition of fern noun from the Oxford Advanced Learner's Dictionary. In: *Oxford Learner's Dictionaries.* Cited 23 December 2022. www.oxfordlearnersdictionaries.com/definition/english/fern

[2] **Dictionary.com**. undated. Lichen. In: *www.dictionary.com*. Cited 23 December 2022. www.dictionary.com/browse/lichen

[3] **Oxford Learner's Dictionaries**. undated. Definition of moss noun from the Oxford Advanced Learner's Dictionary. In: *Oxford Learner's Dictionaries.* Cited 23 December 2022. www.oxfordlearnersdictionaries.com/definition/english/moss

[4] **FAO.** 2022. Planted forests. In: *Food and Agriculture Organization of the United Nations.* Cited 23 December 2022. www.fao.org/forestry/plantedforests/en

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